Benthic TMDL Development:

Stressor Identification for the Jackson River, Virginia

Submitted to

Virginia Department of Environmental Quality

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Final Report

Executive Summary

Background

This report identifies and characterizes the stressor(s) responsible for the biological impairments on the Jackson River. The Jackson River originates in Highland County in southwestern Virginia, and extends to the confluence of the Jackson River with the Cowpasture River in Botetourt County, where the two rivers join to form the James River. The Jackson River flows through sections of Alleghany, Bath, Craig, and Highland Counties, as well as the Cities of Covington and Clifton Forge. The Gathright Dam regulates the stream flow in the Jackson River.

The impaired segment on the Jackson River has a total mileage of 24.21 miles. It is listed for dissolved oxygen and General Standard benthic impairments (DEQ, 2004). The upstream limit of the impaired segment is below the Covington City Water Treatment Plant intake, and its downstream limit is at the confluence of the Jackson and Cowpasture Rivers. The impairments include the following:

- Dissolved oxygen impairment, extending from river mile 24.21 downstream to river mile 13.00 (11.21 miles of the impairment segment).

- General standard benthic impairment, extending from river mile 24.21 to river mile zero, which is the confluence of the Jackson River with the Cowpasture River (24.21 miles of the impairment segment).

Stressor Identification

The stressor identification for the biologically impaired segment of the Jackson River was performed using the available biological and water quality monitoring data. In addition, Discharge Monitoring Reports (DMR) and Nutrient Monitoring Reports (NMR); Toxicity Testing, Whole Effluent Toxicity (WET) data; and special studies were also used in the identification of the stressors on the Jackson River. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA 2000).

The identification of the most probable cause of biological impairment in the Jackson River was based on evaluations of candidate stressors that can potentially impact the river. The 2004 Water Quality Assessment 305(b)/303(d) Integrated Report Fact Sheet identified “nutrient and organic enrichment” as possible sources of biological impairment. Therefore, these pollutants were considered in the evaluation of candidate stressors along with other probable stressors such as pH, temperature, dissolved oxygen, sediment, ammonia, flow modification, and toxic compounds. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Furthermore, potential stressors were classified as a non-stressor, possible stressor, or most probable stressor.

Non-Stressors:

The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact, were considered as non-stressors. Based on the data analyzed, temperature, pH, metals, organics and sediment, as well as non-point sources loading under wet-weather flow were eliminated as stressors in the impaired segment of the Jackson River.

Possible Stressors:

The stressors with data indicating possible links, but inconclusive data, are considered as possible stressors. The results indicate that Total Dissolved Solids (TDS) with the associated toxicity, low-dissolved oxygen, and flow modification are possible stressors to the benthic community in the Jackson River.

Most Probable Stressors:

The stressors with the most complete data linking them to the poorer benthic community are considered as most probable stressors. The results indicate that excessive nutrient loading leading to excessive periphyton growth are adversely impacting the biological communities in the impaired segment of the Jackson River.

Stressor Identification Summary

In summary, the data analysis shows that the common "end-point stressor" is the excessive periphyton growth and accumulation in the Jackson River causing the benthic impairment. This excessive periphyton growth is caused by the excessive nutrients in the river.

Consequently, the periphyton issue in the Jackson River would be addressed through a reduction in nutrient (particularly phosphorus) loadings.

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1.0 Introduction

Total Maximum Daily Load (TMDL) development for biological impairment requires a methodology to identify impairment causes and to determine pollutant reductions that will allow streams to attain their designated uses. The identification of the pollutant(s), or *stressor(s)*, responsible for the impaired biological communities is an important first step in developing a TMDL that accurately specifies the pollutant load reductions necessary for the river to comply with Virginia's water quality standards. This report details the steps used to identify and characterize the stressor(s) responsible for biological impairments on the Jackson River. The first section of this report presents the regulatory guidance and defines the applicable water quality criteria for biological impairment. In the subsequent sections of this report, watershed and environmental monitoring data collected on the Jackson River are presented and discussed. Stressors, which may be impacting the river, are then analyzed in the stressor identification section. Based on this analysis, candidate stressors impacting benthic invertebrate communities in the river are identified. A TMDL will be developed for the stressor identified as the most probable cause of biological impairment in the Jackson River as outlined in the EPA Stressor Identification Guidance (EPA 2000).

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to develop and regulate a more effective TMDL process. DEQ is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. DEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA, passed by the Virginia General Assembly in 1997), and coordinates public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs statewide with federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of bacterial contamination (DEQ, 2001).

As required by the Clean Water Act and WQMIRA, DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the Section 303(d) List of Impaired Waters. In addition to Section 303(d) List development, WQMIRA directs DEQ to develop and implement TMDLs for listed waters (DEQ, 2001a). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Jackson River Description and Impairment Listing

The Jackson River flows through a narrow valley, with mountain peak elevations of approximately 2,500 feet above mean sea level. The headwaters of the Jackson River originate in Highland County in southwestern Virginia, and extend to the confluence of the Jackson River with the Cowpasture River in Botetourt County, where the two rivers join to form the James River. The Jackson River flows through sections of Alleghany, Bath, Craig, and Highland Counties, as well as the Cities of Covington and Clifton Forge. The Gathright Dam regulates the stream flow in the Jackson River.

The Jackson River was initially listed on Virginia's 1996 Section 303(d) Total Maximum Daily Load Priority List and Report (DEQ, 1996), and was subsequently included on Virginia's 1998 and 2002 Section 303(d) Lists of Impaired Waters (DEQ, 2002) and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2004).

The impaired segment of the Jackson River, included in the 2004 305(b)/303(d) Integrated Report, is 25.24 miles long, from its upstream limit immediately below the Covington City Water Treatment Plant intake to its downstream limit at the confluence of the Jackson and Cowpasture Rivers. The impairments include the following:

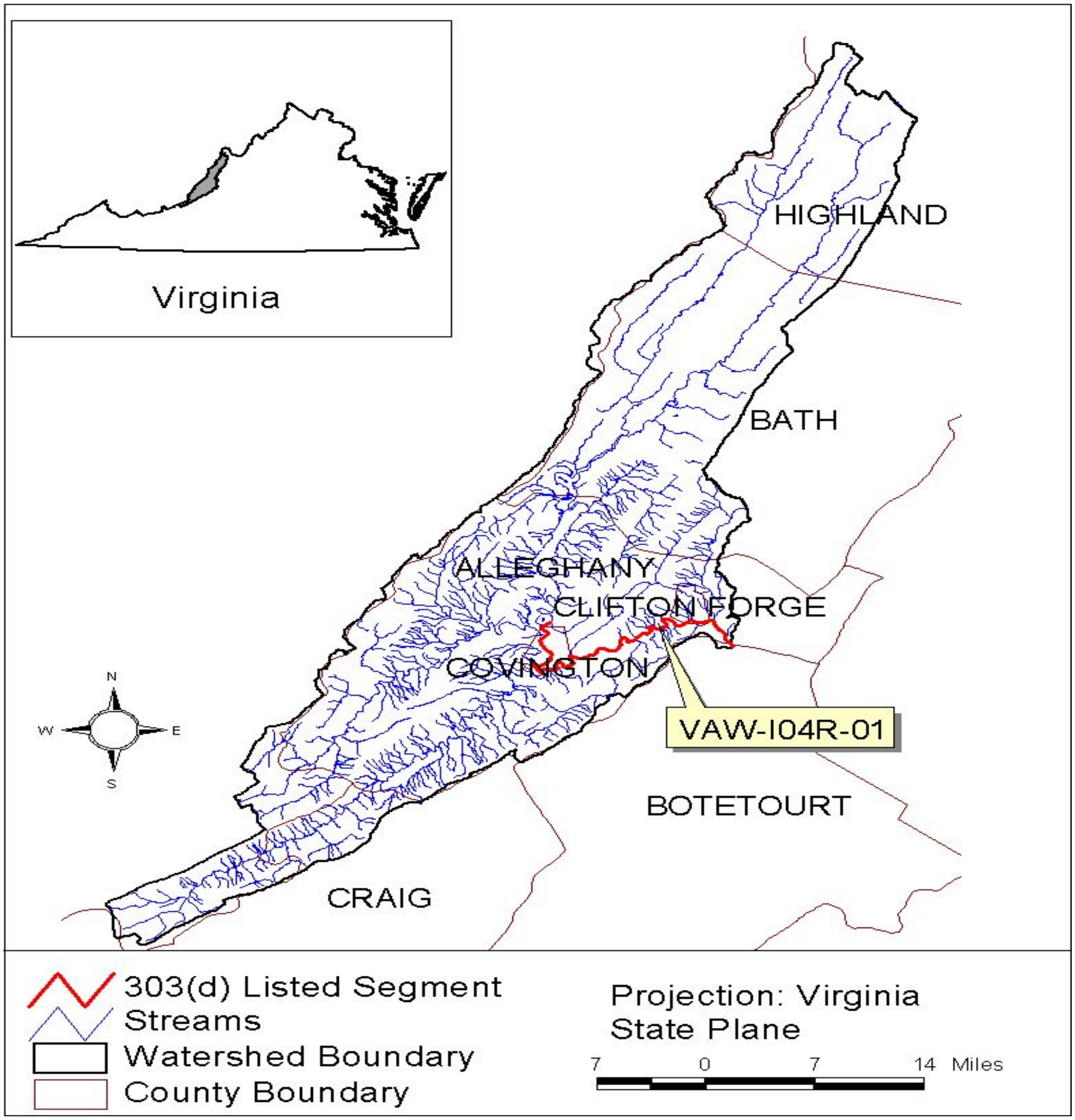
- Dissolved oxygen impairment, extending from river mile 24.21 downstream to river mile 13.00 (11.21 miles of the impairment segment).

- General standard benthic impairment, extending from river mile 24.21 to river mile zero, which is the confluence of the Jackson River with the Cowpasture River (24.21 miles of the impairment segment).

- Bacteria impairment and failure to attain the primary contact recreation and aquatic life uses, extending from river mile 25.24 to river mile 21.86 (3.38 miles of the impairment segment). However, the recent data supplied by the DEQ indicates that the fecal coliform bacteria concentrations are false positive results due to Klebsiella pneumoniae. Consequently, EPA concurred that a bacteria TMDL is not required for the Jackson River (Memorandum from Jon Capacasa, Director Water Protection Division EPA Region 3, to Ellen Gilinsky VADEQ, 2005).

Consequently, this report addresses the impaired segment, with a total mileage of 24.21 miles, for General Standard benthic impairments. Figure 1-1 depicts this impaired segment.

Figure 1-1: Jackson River Location and Benthic Impairment Segment



1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *water quality standards* means "provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect public health or welfare, enhance the quality of water, and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

The listed segment defined in Section 1.2 does not support the propagation and growth of aquatic life in the Jackson River, based on the biological assessment surveys conducted on the river.

1.3.2 Water Quality Criteria

The General Standard defined in Virginia Water Quality Standards (9 VAC 25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The General Standard states:

> *"All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."*

The biological assessments conducted on the Jackson River indicate that some pollutant(s) are interfering with attainment of the General Standard, as impaired invertebrate communities have been observed in the listed segment of the river. Although biological assessments are indicative of the impacts of pollution, the specific pollutant(s) and source(s) are not necessarily known based on biological assessments alone.

2.0 Watershed Characterization

The physical conditions of the Jackson River watershed were characterized using a geographic information system (GIS) developed for the watershed. The purpose of the watershed characterization was to provide an overview of the conditions in the watershed related to the benthic impairment present in the river. Information contained in the watershed GIS was used in the stressor identification analysis, as well as for the subsequent TMDL development. In particular, watershed physical features such as topography, soils types, and land use conditions were characterized. In addition, the number and location of permitted discharge facilities and DEQ monitoring stations in the watershed were summarized.

2.1 Physical Characteristics

Important physical characteristics of the Jackson River watershed that may be contributing to the benthic impairment were analyzed using GIS coverages developed for the area. GIS coverages for the watershed boundary, stream network, topography, soils, land use, and ecoregion of the watershed were compiled and analyzed.

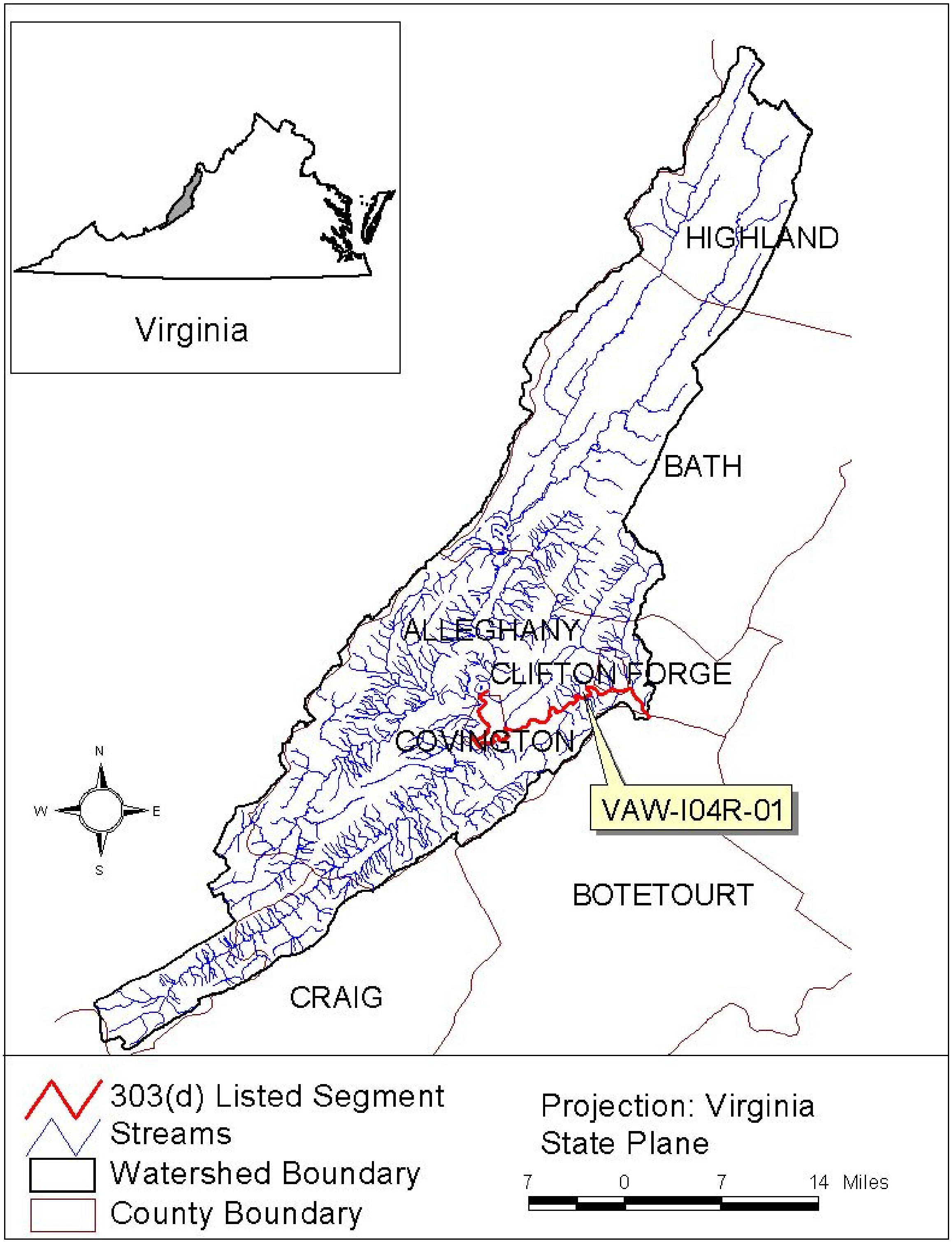
2.1.1 Watershed Location and Boundary

The Jackson River watershed flows through sections of Allegheny, Bath, Craig, and Highland Counties, as well as the Cities of Covington and Clifton Forge (Figure 2-1). Small sections of the watershed are located in West Virginia. The watershed is approximately 584,686 acres or 916 square miles. Approximately 80 percent of the runoff generated by this drainage area is controlled by the Gathright Dam.

2.1.2 Stream Network

The stream network for the Jackson River watershed was obtained from the USGS National Hydrography Dataset (NHD). The stream network and benthic impairment segments are presented in Figure 2-1.

Figure 2-1: Stream Network for the Jackson River Watershed



2.1.3 Topography

A digital elevation model (DEM) was used to characterize topography in the watershed. DEM data obtained from BASINS show that elevation in the watershed ranges from 912 to 4,116 feet above mean sea level, with an average elevation of 2,223 feet.

2.1.4 Soils

The Jackson River watershed soil characterization was based on the NRCS State Soil Geographic (STATSGO) Database for Virginia and West Virginia. There are fifteen general soil associations present in the Jackson River watershed (Table 2-1). The majority of soils in the watershed are comprised of the Wallen-Dekalb-Drypond, Berks-Weikert-Laidig, Shottower-Laidig-Weikert, and Wallen-Dekalb-Drypond soils associations. Combined, these four soil associations account for almost 85 percent of the soils in the watershed.

Table 2-1: Soil Types in the Jackson River Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
VA001	Berks-Weikert-Laidig	17.0	B/D
VA003	Frederick-Carbo-Timberville	3.3	B/D
VA004	Moomaw-Jefferson-Alonzville	3.4	C
VA005	Wallen-Dekalb-Drypond	54.2	C
VA016	Shottower-Laidig-Weikert	8.2	C
VA072	Opequon-Berks-Blackthorn	4.0	C
VA073	Mandy-Trussel-Gauley	0.1	C
VA075	Calvin-Dekalb-Hazleton	0.9	A/B/C
WV002	Frederick-Carbo-Timberville	1.4	B/C
WV003	Cateache-Berks-Shouns	0.2	B/C
WV022	Weikert-Berks-Dekalb	0.1	B/C/D
WV048	Mandy-Trussel-Gauley	0.03	C
WV119	Wallen-Dekalb-Drypond	5.1	B/C/D
WV120	Shottower-Laidig-Weikert	1.3	B/C
WV121	Moomaw-Jefferson-Alonzville	0.8	B/C

Source: State Soil Geographic (STATSGO) Database for Virginia and West Virginia

The hydrologic soil groups of each of the soil associations are also presented in Table 2-1. The hydrologic soil groups represent the different levels of soil infiltration capacity. Hydrologic soil group "A" designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the ground water system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water, resulting in more rainfall delivered to surface waters in the form of runoff. Descriptions of the hydrologic soil groups are presented in Table 2-2.

Table 2-2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover.

2.1.5 Land Use

The land use characterization was based on USGS National Land Cover Data (NLCD). The distribution of land uses in the Jackson River watershed, by land area and percentage, is presented in Table 2-3. Forested lands (89.3%) and agricultural lands (8.5%) represent the dominant land uses in the watershed. Brief descriptions of land use classifications are presented in Table 2-4. Figure 2-2 displays a map of the land uses within the watershed. Forested lands are ubiquitous throughout the watershed. Agricultural lands are most concentrated in the northern headwaters of the basin. Small percentages of urban and industrial areas are associated with the Cities of Covington and Clifton Forge.

Table 2-3: Jackson River Watershed Land Use Distribution

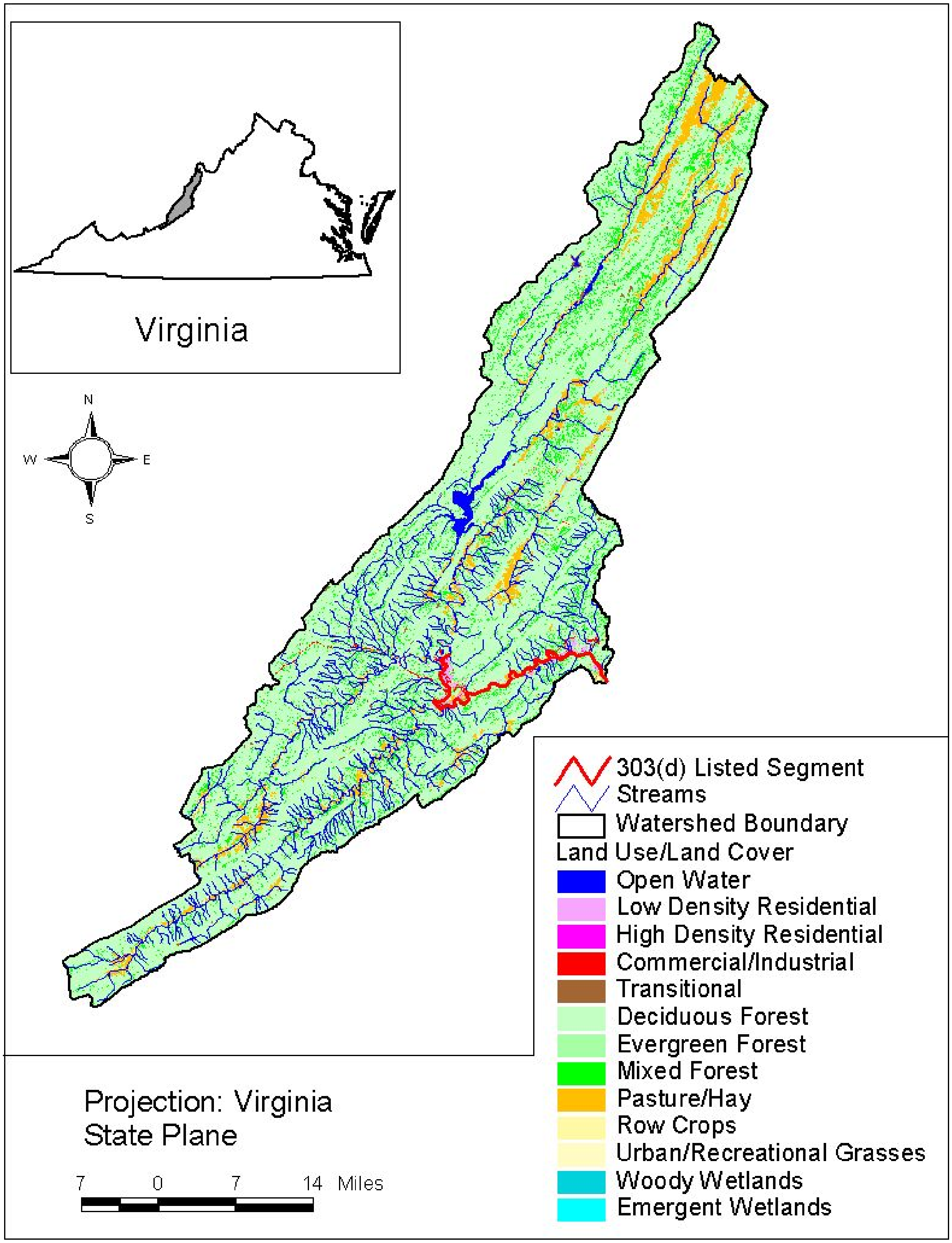
General Land Use Category	NLCD Land Use Type	Acres	Percent of Watershed	Total Percent
Water/ Wetlands	Open Water	4536.0	0.78	**0.8**
	Woody Wetlands	215.7	0.04	
	Emergent Herbaceous Wetlands	178.3	0.03	
Developed	Low Intensity Residential	3253.7	0.56	**0.9**
	High Intensity Residential	22.5	0.004	
	Commercial/Industrial/Transportation	1889.6	0.32	
Agriculture	Pasture/Hay	43541.7	7.45	**8.5**
	Row Crop	6233.7	1.07	
Forest	Deciduous Forest	435637.1	74.57	**89.3**
	Evergreen Forest	20336.1	3.48	
	Mixed Forest	65758.8	11.26	
Other	Transitional	2496.2	0.43	**0.4**
	Urban/Recreational Grasses	131.9	0.02	
Total		**584,686**	**100**	**100**

Table 2-4: Descriptions of NLCD Land Use Types

Land Use Type	Description
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water
Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential	Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.
Commercial/ Industrial/ Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crop	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.
Transitional	Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)
Urban/ Recreational Grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Source: National Land Cover Data (NLCD)

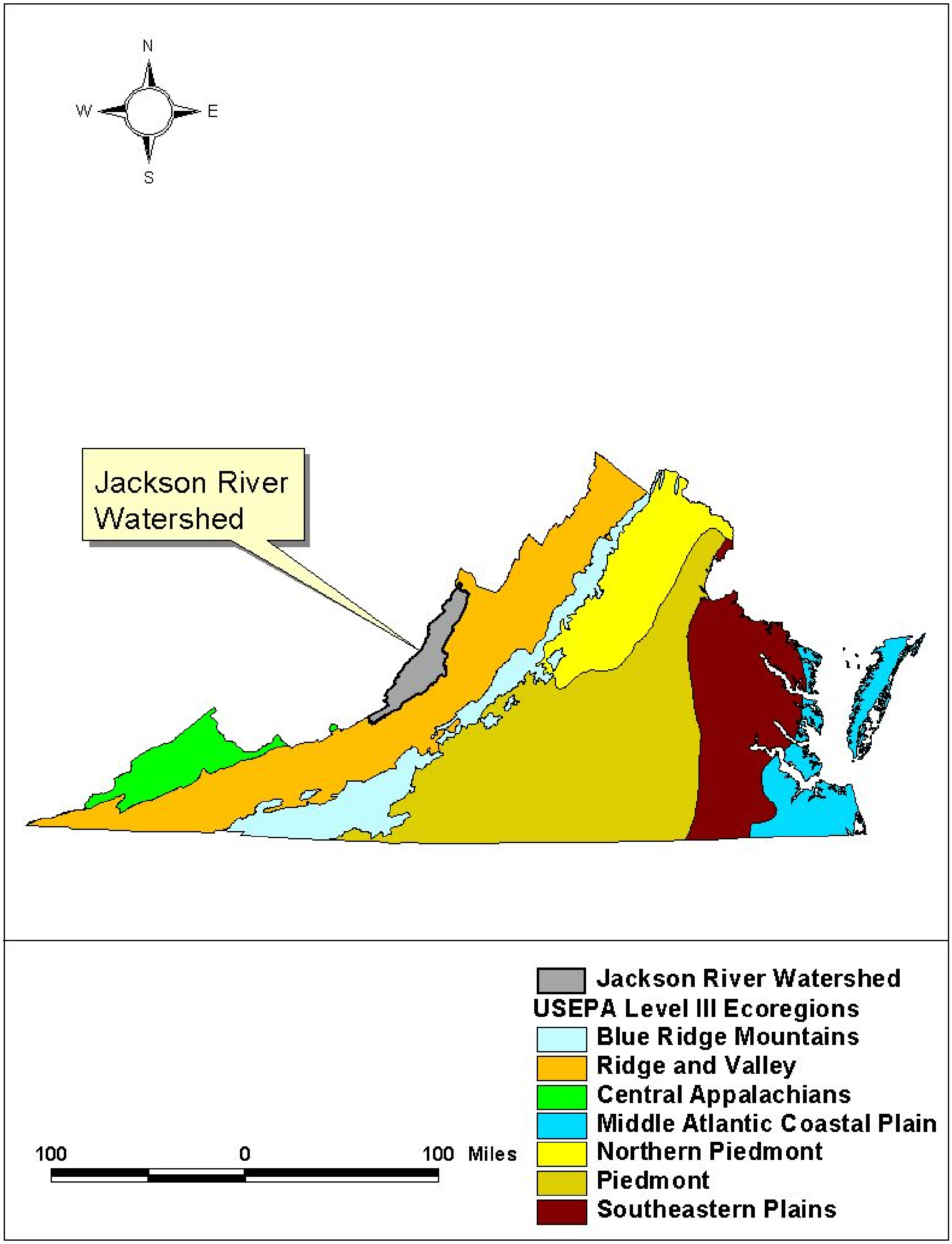
Figure 2-2: Land Use in the Jackson River Watershed



2.1.6 Ecoregion Classification

The Jackson River watershed is located in the Central Appalachian Ridge and Valley ecoregion, USEPA Level III classification number 67 (Woods et al., 1999). The location of the Jackson River watershed within this ecoregion is presented in Figure 2-3. The Ridge and Valley ecoregion extends from Wayne County, Pennsylvania, through Virginia in a southwesterly direction, and is characterized by alternating forested ridges and agricultural valleys; approximately 50 percent of the region is forested. The Ridge and Valley ecoregion is situated between higher elevation mountainous regions with greater forest cover. The region's roughly parallel ridges and valleys are comprised of a variety of geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Elevation in the region ranges from about 500 to 4,300 feet above mean sea level.

Figure 2-3: Virginia Level III Ecoregions



2.2 Permitted Discharge Facilities

There are 15 facilities holding active individual discharge permits in the Jackson River watershed. The permit number, type, permitted flow, receiving waterbody, and status of each of the facilities holding individual permits are presented in Table 2-5, and their locations are presented in Figure 2-4. There are also a total of 18 general permits in the Jackson River watershed; 11 stormwater permits issued to industrial sites, 3 permits issued to domestic sewage facilities, 2 permits issued to mines, 1 stormwater permit issued to a construction site, and 1 permit issued to a concrete facility. Additional information regarding the general permits is presented in Table 2-6.

Table 2-5: Facilities Holding Individual Permits in the Jackson River Watershed

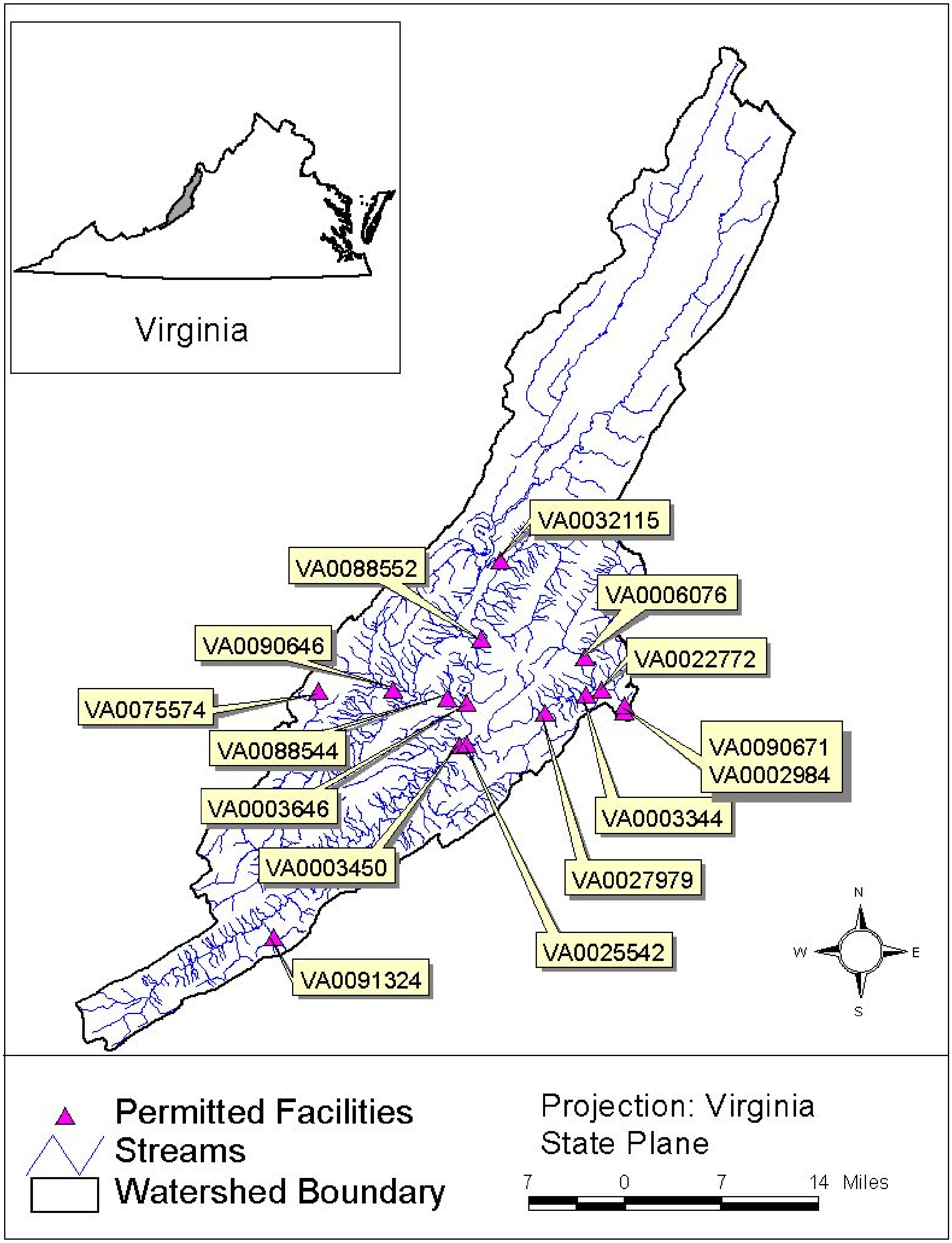
Permit Number	Facility Name	Facility Type	Design Flow (gpd)[1]	Receiving Waterbody	Status
VA0027979	Alleghany County - Low Moor STP	Municipal	500,000	Jackson River	Active
VA0003450	Applied Extrusion Technologies	Industrial	1,000,000	Jackson River	Active
VA0088544	Boys Home Inc STP	Municipal	24,000	Dunlap Creek	Active
VA0022772	Clifton Forge City STP	Municipal	2,000,000	Jackson River	Active
VA0006076	Clifton Forge Water Treatment Plant	Industrial	50,000	Smith Creek	Active
VA0025542	Covington City STP	Municipal	3,000,000	Jackson River	Active
VA0003344	CSX Transportation Inc - Clifton Forge	Industrial	25,000	Jackson River	Active
VA0091324	DGIF Paint Bank Fish Cultural Station	Industrial	2,900,000	Paint Bank Branch	Active
VA0003646	MeadWestvaco Packaging Resource Group	Industrial	32,890,000	Jackson River	Active
VA0032115	Morris Hill STP	Municipal	15,000	Jackson River	Active
VA0002984	Parker Hannifin Powertrain Division	Industrial	208,000	Jackson River	Active
VA0088552	Sponaugle Subdivision	Municipal	16,000	Jackson River	Active
VA0090646	Tanglewood Manor Home for Adults	Municipal	18,000	Ogle Creek	Active
VA0075574	VDOT I64 Rest Area - Alleghany County	Municipal	15,000	Jerry's Run	Active
VA0090671	Alleghany Co - Lower Jackson River WWTP	Municipal	2,000,000	Jackson River	Inactive

1: Gallons per Day

Table 2-6: Facilities Holding Active General Permits in the Jackson River Watershed

Permit Number	Facility Name	Permit Type	Receiving Waterbody	Status
VAR102964	Kim Stan Landfill Superfund Site Remedial Action	Stormwater Construction	Jackson River	Active
VAR050759	Alleghany Asphalt Plt – Lowmoor	Stormwater Industrial	Jackson River, UT	Active
VAR050765	Bennett Logging & Lumber Inc	Stormwater Industrial	Jackson River, UT	Active
VAR050713	Bradley Saw Mill Inc	Stormwater Industrial	Ogles Creek	Active
VAR051383	Clifton Forge Water Treatment Plant	Stormwater Industrial	Hazel Hollow	Active
VAR051361	Covington Wastewater Treatment Plant	Stormwater Industrial	Jackson River	Active
VAR050182	General Chemical LLC	Stormwater Industrial	Jackson River	Active
VAR050408	Kestersons Used Parts	Stormwater Industrial	Ogle Creek	Active
VAR050415	Lear Corp - Covington	Stormwater Industrial	Harmon Run	Active
VAR050440	Martin Co Coal Corp - Coal Handling Facility Inc	Stormwater Industrial	Jackson River	Active
VAR051392	Peters Mountain Landfill	Stormwater Industrial	Harmon Run	Active
VAR050393	Westvaco - Low Moor Converting Plant	Stormwater Industrial	Jackson River, UT	Active
VAG402026	Rothe, Martin Residence	Domestic Sewage	East Branch of Dry Creek	Active
VAG402094	Shirley Residence	Domestic Sewage	Anderson Hollow, UT	Active
VAG402098	Rogers Residence James O and Iris L	Domestic Sewage	Bens Run	Active
VAG840047	Boxley Materials Company - Alleghany Plant	Mines	Karnes Creek	Active
VAG842020	Boxley Materials Company - Alleghany Plant	Mines	Karnes Creek	Active
VAG110170	Cliftondale Redi Mix	Stormwater Concrete	Wilson Creek, UT	Active

Figure 2-4: Facilities with Individual Permits in the Jackson River Watershed



2.3 DEQ Monitoring Stations

DEQ has several active monitoring stations on the Jackson River, which are used for biological and ambient water quality monitoring.

DEQ's biological monitoring program uses several methods and metrics to assess the ecological health of freshwater streams and rivers. These methods and metrics are based on the assessment of the benthic macroinvertebrate community. They consist of a modified version of the EPA Rapid Bioassessment Protocols II (RBPII), the Virginia Stream Condition Index (SCI), and the inspection of several habitat variables to derive Habitat Assessment Scores. The result and analysis of the biomonitoring data is presented in Section 3.1.

DEQ's ambient water quality monitoring collects water samples on a routine schedule at several locations in the Jackson River Watershed. The samples are tested for levels of nutrients, solids, bacteria associated with human and animal wastes, toxic metals, pesticides and harmful organic compounds. DEQ also perform on-the-spot field tests for dissolved oxygen, pH, temperature, salinity, and additional indications of water quality. The analysis of the water quality data in the Jackson River's impairment is presented in Section 3.2.

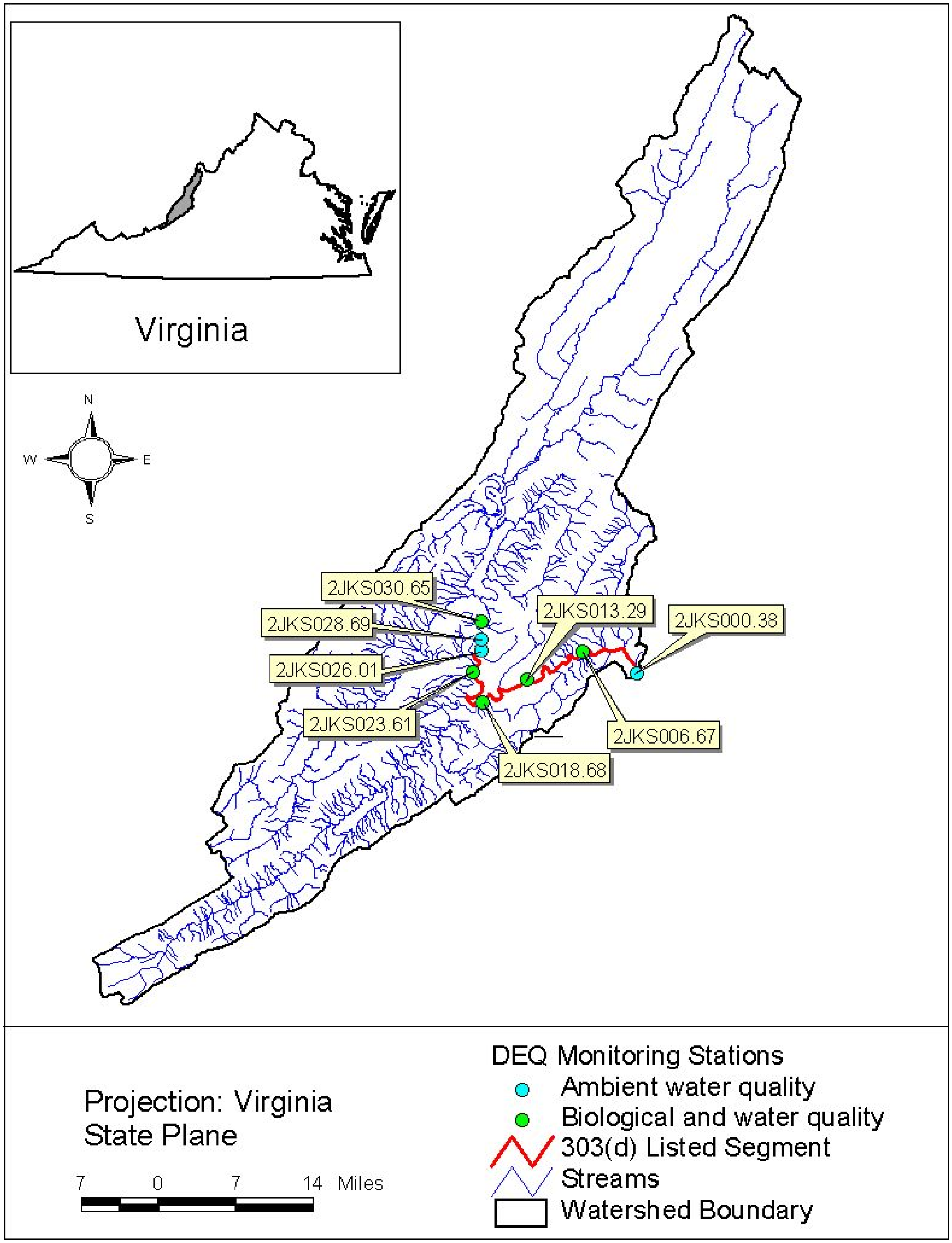
A summary list of the DEQ monitoring stations located on the Jackson River is presented in Table 2-7, and the locations of these stations are presented in Figure 2-5. It should be noted that additional water quality monitoring data were collected at tributary stations located within the Jackson River watershed. These data were evaluated as part of the benthic stressor analysis; however, because the biological impairment is located on the mainstem Jackson River, discussion of water quality data in this report is limited to those data collected at mainstem Jackson River stations on or above the impaired biological segment. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. For instance, station name 2JKS013.29 comprises of the abbreviated name *2JKS* and is at river mile *013.29*. The river mile number represents the distance from the mouth of the creek.

Table 2-7: Summary of Monitoring Stations on the Jackson River

Station ID	Station Location	Latitude[1]	Longitude[1]	Station Type	Period Of Record
2JKS000.38	At Rt. 727 Iron Gate	37.788	-79.781	Ambient water quality	1974-2005
2JKS006.67	At Low Water bridge near Dabney Lancaster, Alleghany Co.	37.811	-79.854	Ambient and biological	1988-2003
2JKS013.29	At Rt. 696 near Low Moor Cave, Alleghany Co.	37.781	-79.928	Ambient and biological	1989-2003
2JKS018.68	At Rt. 18 Bridge in Covington, Alleghany Co.	37.756	-79.987	Ambient and biological	1974-2001
2JKS023.61	At City Park in Covington, Alleghany Co.	37.789	-80.001	Ambient and biological	1979-2005
2JKS026.01	At Covington Water Filtration Plant	37.811	-78.011	Ambient water quality	2003-2005
2JKS028.69	North of Intervale	37.823	-78.011	Ambient water quality	2004
2JKS030.65	At Rt. 687 Bridge, Alleghany Co.	37.842	-79.989	Ambient and biological	1988-2005

[1] In Decimal Degrees

Figure 2-5: DEQ Monitoring Stations in the Jackson River Watershed

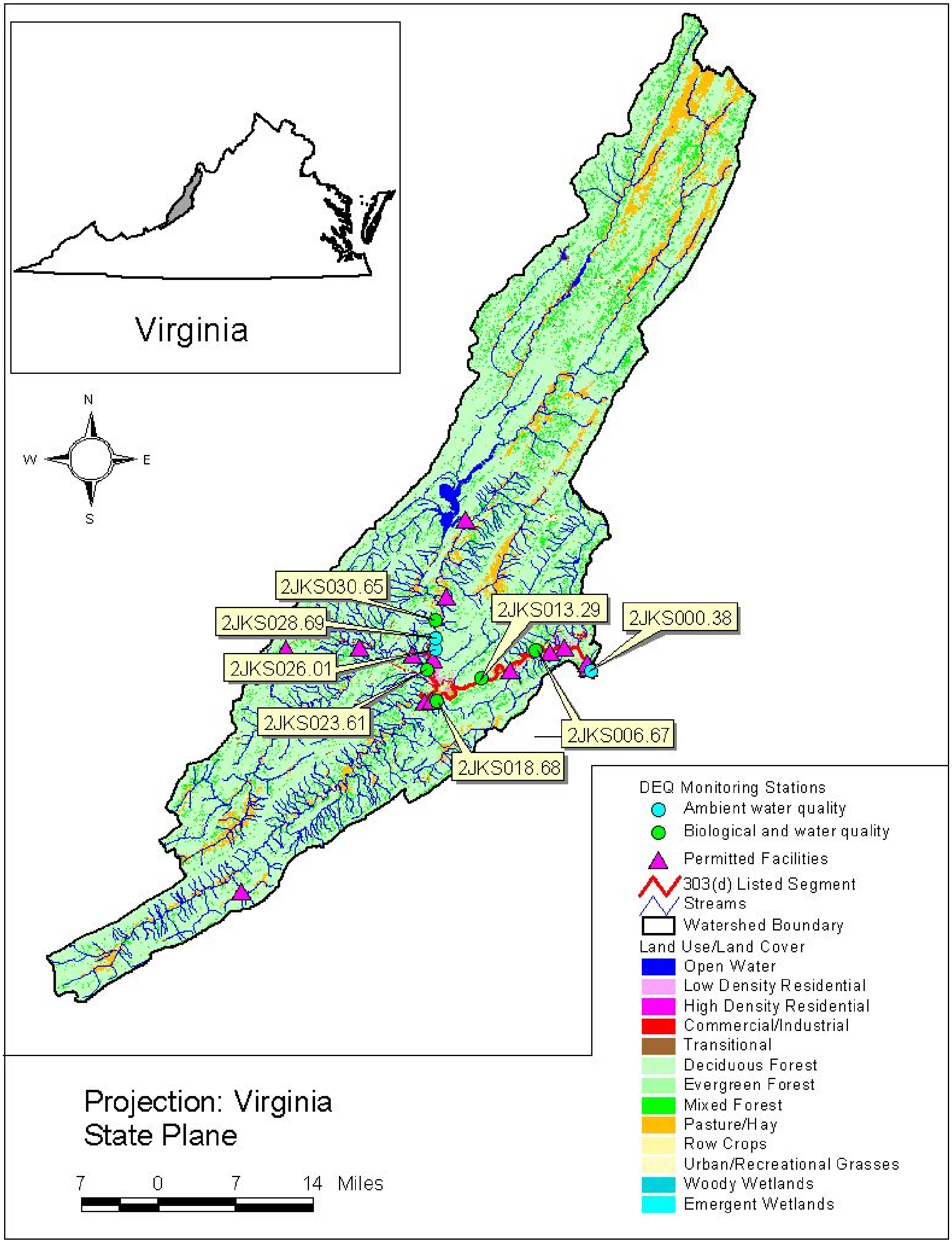


The benthic invertebrate communities at stations 2JKS006.67, 2JKS013.29, 2JKS018.68, and 2JKS023.61 are classified as impaired based on DEQ bioassessments. Station 2JKS030.65 is the biological monitoring station that was used as a reference station for bioassessments. Additional water quality data were collected at stations 2JKS000.38, 2JKS026.01, and 2JKS028.69 on the Jackson River mainstem. A detailed discussion of environmental monitoring data is presented in Section 3.0.

2.4 Overview of the Jackson River Watershed

Forested lands (89.3%) and agricultural lands (8.5%) represent the dominant land uses in the Jackson River watershed. There are 15 facilities holding individual discharge permits in the watershed, and 18 facilities holding active general permits. Biological monitoring has been conducted by DEQ at five mainstem Jackson River stations on or upstream of the impairment biological segment, and DEQ has collected ambient water quality data at eight mainstem stations in the watershed. The land use and the locations of the facilities and monitoring stations in the watershed are shown in the summary map presented in Figure 2-6.

Figure 2-6: Overview of the Jackson River Watershed



3.0 Environmental Monitoring

The first step in benthic TMDL development is the identification of the pollutant stressor(s) affecting the benthic community. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used to determine the primary stressor affecting the biologically impaired segment of the Jackson River. Analyzed data sources included available biological and water quality monitoring data, Discharge Monitoring Reports (DMR) from the permitted facilities, and special studies conducted on the Jackson River. The collection period, content, and monitored sites for these data sources are summarized in Table 3-1. The locations of permitted discharge facilities and monitoring stations were presented previously in Figures 2-4 and 2-5.

Table 3-1: Inventory of Environmental Monitoring Data for the Jackson River

Data Type	Source	Period	DEQ Monitoring Stations								Permitted Facilities
			2JKS000.38	2JKS006.67	2JKS013.29	2JKS018.68	2JKS023.61	2JKS026.01	2JKS028.69	2JKS030.65	
Biological Monitoring	DEQ	1994-2004		X	X	X	X		X	X	
Ambient Water Quality Monitoring	DEQ	1989-2005	X	X	X	X	X	X	X	X	
Field Water Quality Monitoring	DEQ	1994-2004		X	X	X	X			X	
Ambient Water Quality Monitoring	MeadWestvaco	1998-2001									X
Biological Monitoring	MeadWestvaco	1998-1999									X
Discharge Monitoring Reports (DMR)	DEQ	1999-2005									X
Nutrient Monitoring Reports	DEQ	2004-2005									X
Special Studies	MeadWestvaco	1997-2001									X

3.1 Biological Monitoring Data

Based on biomonitoring data conducted from 1994 to 2004, the 2004 Virginia Section 303(d) list indicates that the benthic community in the Jackson River is impaired for 24.21 miles, beginning at river mile 24.21 and extending to the confluence of the Jackson River and the Cowpasture River. In addition, the Jackson River is listed as impaired, due to low dissolved oxygen for 11.21 miles of the biologically impaired segment extending from river mile 24.21 to river mile 13.00.

The biological conditions of the Jackson River were evaluated using a modified version of the EPA Rapid Bioassessment Protocols II (RBPII) to assess the river's benthic invertebrate communities; the Virginia Stream Condition Index (SCI); and the Habitat Assessment Scores.

3.1.1 EPA Rapid Bioassessment Protocols (RBPII)

VADEQ's RBPII follows a paired reference approach using upstream stations located in the same watershed. The protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures. Candidate RBPII metrics, as specified in EPA's Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers, Second Edition (Barbour et al., 1999), are presented in Table 3-2. The RBPII Scores calculated for the Jackson River biological monitoring stations and used to specify the Section 303(d) listings are presented in Table 3-3. DEQ field data sheets and bioassessment forms completed for each biological assessment conducted on the mainstem Jackson River contained the following information:

- Assessment ratings for each station for each survey event
- The numbers and types of macroinvertebrates present at each station
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of each survey

Table 3-2: Candidate RBPII Metrics Specified in Barbour et al. (2002)

Category	Metric	Definition	Expected Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/ Intolerance Measures	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of the macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures dominance of the most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from water column or sediment	Variable
	% Grazers and Scrapers	Percent of macrobenthos that scrape or graze upon periphyton	Decrease
Other Measures	Hilsenhoff Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

Table 3-3: RBPII Scores at Jackson River Monitoring Stations

Station	Year	Season	RBPII Score	Assessment
2JKS006.67	1998	Spring	47.83	Moderately Impaired
		Fall	33.33	Severely Impaired (BPJ)[1]
	1999	Spring	34.78	Severely Impaired (BPJ)
		Fall	39.13	Severely Impaired (BPJ)
	2000	Spring	21.47	Severely Impaired (BPJ)
		Fall	37.50	Moderately Impaired
	2001	Spring	29.17	Moderately Impaired
		Fall	N/A	Not Sampled
2JKS013.29	1998	Spring	30.43	Moderately Impaired
		Fall	12.50	Severely Impaired
	1999	Spring	26.09	Severely Impaired (BPJ)
		Fall	43.48	Severely Impaired (BPJ)
	2000	Spring	13.04	Severely Impaired
		Fall	16.67	Severely Impaired
2JKS018.68	1998	Spring	68.75	Moderately Impaired
		Fall	41.67	Moderately Impaired
	1999	Spring	30.43	Severely Impaired (BPJ)
		Fall	39.13	Severely Impaired (BPJ)
	2000	Spring	21.74	Severely Impaired (BPJ)
		Fall	16.67	Severely Impaired
2JKS023.61	1998	Spring	13.04	Severely Impaired
		Fall	12.50	Severely Impaired
	1999	Spring	30.43	Severely Impaired (BPJ)
		Fall	26.09	Severely Impaired (BPJ)
	2000	Spring	13.04	Severely Impaired
		Fall	8.33	Severely Impaired
	2001	Spring	12.50	Severely Impaired
		Fall	21.74	Severely Impaired (BPJ)
	2002	Spring	22.73	Severely Impaired (BPJ)
		Fall	N/A	Not Sampled
2JKS030.65	1998	Spring	100.00	Non-impaired
		Fall	100.00	Non-impaired
	1999	Spring	100.00	Non-impaired
		Fall	100.00	Non-impaired
	2000	Spring	100.00	Non-impaired
		Fall	100.00	Non-impaired
	2001	Spring	100.00	Non-impaired
		Fall	100.00	Non-impaired
	2002	Spring	100.00	Non-impaired
		Fall	N/A	Not Sampled

1: Most assessments where RBPII scores resulted in Moderately Impaired designations, the scores were skewed higher by trophic (functional feeding group) level metrics. Using best professional judgment (BPJ) and looking at metrics that are better indicators of pollution tolerance/intolerance, several assessments were changed to severely impaired.

3.1.2 Virginia Stream Condition Index (SCI) Scores

Biological assessment scores derived from biomonitoring data collected on the impaired segment were also calculated using the Virginia Stream Condition Index (SCI) currently being developed by DEQ. The SCI is an eco-regionally-calibrated index comprised of eight metrics that are listed in Table 3-4. SCI scores are considered draft and are used as an additional assessment tool. The reference condition of the SCI Index is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 60 has been proposed for assessing results obtained with the SCI. Streams that score greater than 60 are considered non-impaired, whereas streams that score less than 60 are considered impaired.

Table 3-4: Metrics Used to Calculate the Virginia Stream Condition Index (SCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemoroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemoroptera	Decrease	% Ephemoroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

Calculated SCI scores for the biomonitoring stations located on or above the biologically impaired segment, are presented in Table 3-5. SCI scores calculated for stations 2JKS06.67, 2JKS013.29, 2JKS018.68, and 2JKS023.61 were consistently below the proposed impairment cutoff score of 60. Therefore, these stations are considered impaired, and were used to define the biologically impaired segment of the Jackson River. Station 2JKS030.65 served as the reference station for the biological RBPII assessments; biological assessments conducted at this station were consistently above the proposed impairment cutoff score.

Table 3-5: Virginia SCI Scores for the Jackson River

Collection Period	SCI Score					
	2JKS006.67	2JKS013.29	2JKS018.68	2JKS023.61	2JKS028.69	[1]2JKS030.65
Fall 1994	44	33	37	30		80
Spring 1995	40	46	48	24		84
Fall 1995	-	-	40	24		79
Spring 1996	-	-	46	33		87
Fall 1996	28	35	43	16		73
Spring 1997	44	54	61	29		78
Summer 1997	-	-	43	28		74
Fall 1997	39	37	50	18		73
Spring 1998	50	44	62	25		71
Fall 1998	38	34	53	29		79
Spring 1999	40	33	37	33		74
Fall 1999	42	42	48	32		74
Spring 2000	37	28	29	38		82
Fall 2000	42	30	33	28		80
Spring 2001	40	-	-	31		78
Fall 2001	-	-	-	34		79
Spring 2002	-	-	-	38		75
Spring 2003	-	-	-	-		77
Fall 2003	56	50	-	39		73
Spring 2004					80	
Fall 2004					77	
Average	**41.5**	**38.8**	**45.0**	**29.4**	**78.5**	**77.4**

[1]Monitoring Station 2-JKS030.65 was used as the reference station for bioassessments

3.1.3 Habitat Assessment Scores

A suite of habitat variables were visually inspected at the bio-monitoring stations as part of every biological assessment conducted on the Jackson River. These habitat variables are derived using the EPA Rapid Habitat Assessment Guidance for High Gradient Streams (EPA/841/B99/002). Habitat parameters that examined include channel alteration, sedimentation, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. Each parameter was assigned a score from zero to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. Box plots depicting the minimum, maximum, 25th percentile, 50th percentile, and 75th percentile of selected habitat parameters scored at each of the monitoring stations are presented in Figures 3-1 to 3-3. Box plots of all scored habitat parameters are presented in Appendix A.

Habitat conditions at the biological monitoring stations declined as sampling moved from upstream to downstream (Figures 3-1 and 3-2, Appendix A). Conditions decreased after stations 2JKS030.65 (the biological reference station) and 2-JKS028.69 then gradually increased at the most downstream stations. This decrease corresponds to the presence of the Cities of Covington and Clifton Forge, and several large point sources, which are present in the area (Figure 2-4). Total habitat scores, defined as the sum of all habitat parameter scores, showed a similar trend, decreasing after stations 2JKS030.65 and 2-JKS028.69 then gradually increasing as sampling moved from upstream to downstream (Figure 3-3).

Figure 3-1: Substrate Embeddedness Scores for Jackson River Monitoring Stations

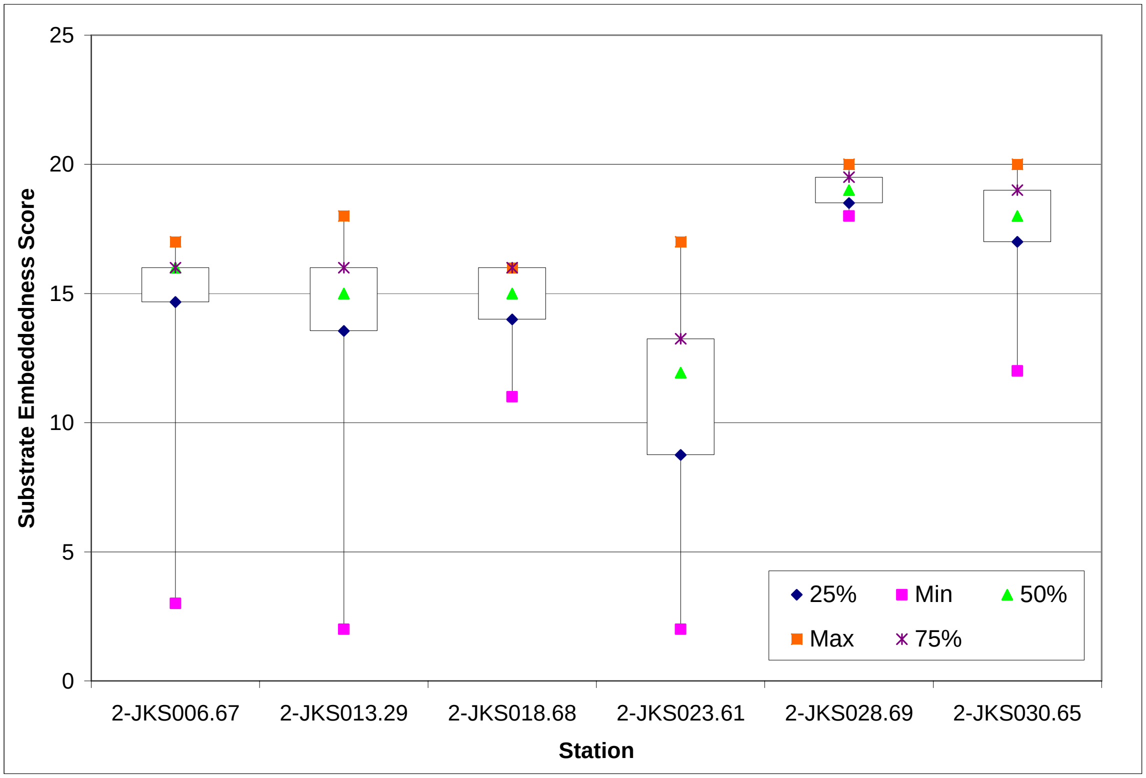


Figure 3-2: Riparian Vegetation Scores for Jackson River Monitoring Stations

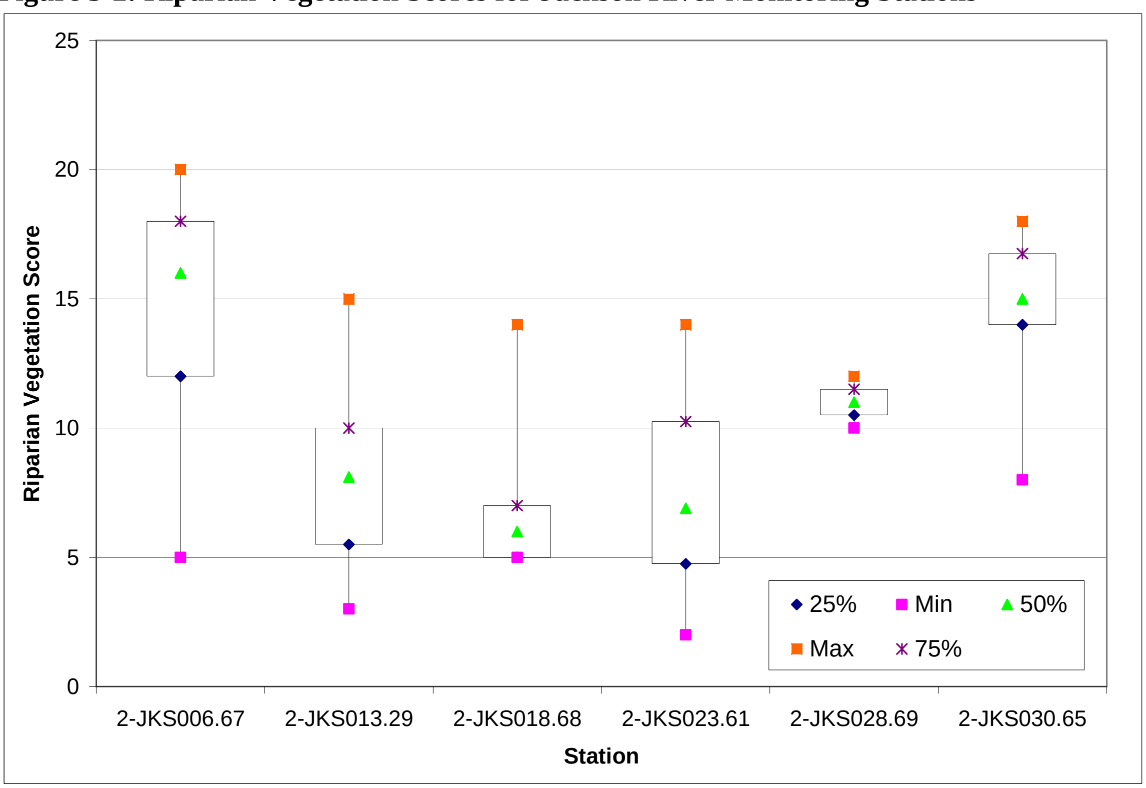
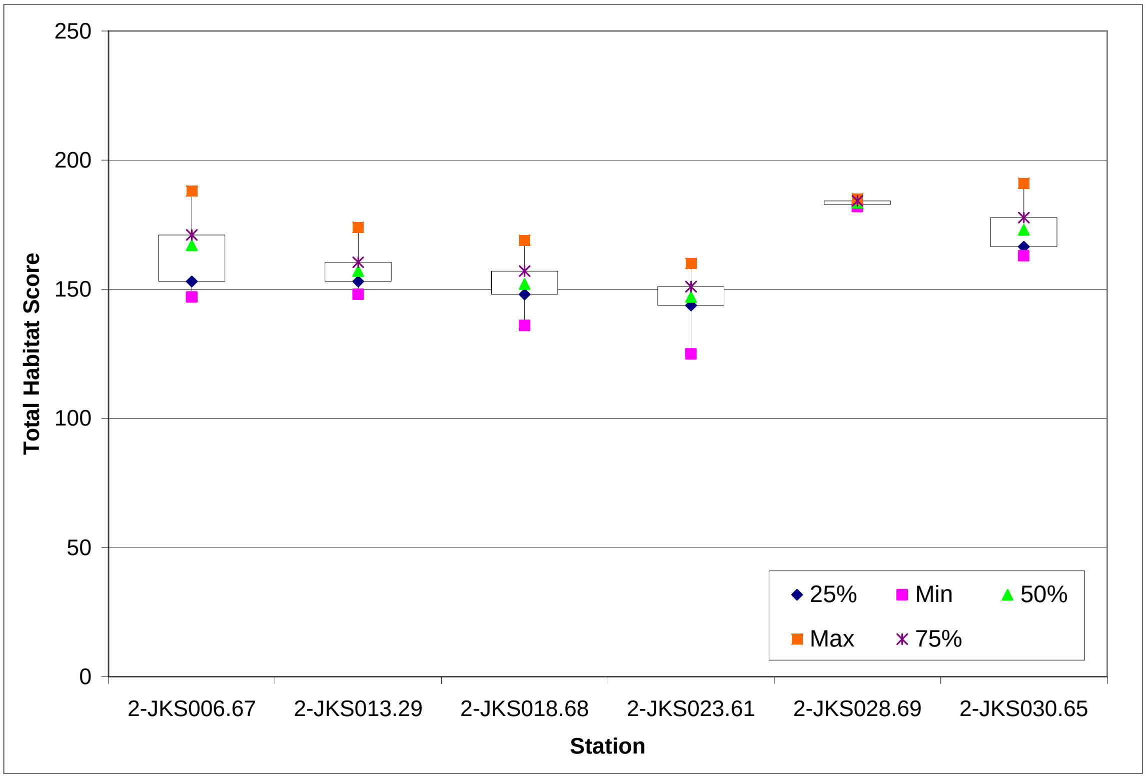


Figure 3-3: Total Habitat Scores for Jackson River Monitoring Stations



3.2 Water Quality Monitoring

There are eight DEQ ambient water quality monitoring stations located on the mainstem Jackson River on or above the biologically impaired segment. Table 3-6 presents the information for each DEQ ambient monitoring. Monitoring stations 2JKS000.38, 2JKS006.67, 2JKS018.68, 2JKS023.61, and 2JK030.65 represent the largest sources of water quality data available for the study area.

Table 3-6: DEQ Ambient Water Quality Monitoring Stations on the Jackson River

Station Id	Station Location	Period of Record	No. Sampling Events
2JKS000.38	Route 727 Iron Gate	1989-2005	4703
2JKS006.67	Low Water Bridge Near Dabney Lancaster	1989-2004	4299
2JKS013.29	Off Route 696, Above Low Moore- Alleghany	1989-2005	404
2JKS018.68	Route 18 Bridge- City of Covington	1989-2003	4049
2JKS023.61	Covington Gage City Park	1989-2005	4775
2JKS026.01	Route 687 Bridge, Clearwater Park Alleghany	2003-2005	70
2JKS028.69	North of Intervale	2004	209
2JKS030.65	Route 687 Bridge Clearwater Park Alleghany	1989-2005	2990

Additionally, the MeadWestvaco Packaging Resource Group, the largest facility discharging into the Jackson River, has collected substantial ambient water quality data on the river. Section 3.2.5 presents the review and analysis of these data.

3.2.1 DEQ Instream Water Quality Data

This Section presents the instream water quality data collected on the Jackson River by DEQ. When the same parameter is recorded at more than three stations, statistics are presented through box plots depicting the minimum, maximum, 25th percentile, 50th percentile, and 75th percentile of the water quality parameter observed at each of the monitoring stations.

3.2.1.1 Compliance with Water Quality Standards (Temperature, pH, and DO)

The Jackson River is classified as a Class IV water body, as defined in the Virginia Water Quality Standards (9 VAC 25-260-50). This stream section encompasses the biologically impaired segment of the Jackson River; thus, water quality parameters in the biologically impaired segment must meet the Class IV standards presented in Table 3-7.

Table 3-7: Water Quality Standards for the Impaired Segment of the Jackson River

Class	Description of Waters	Dissolved Oxygen (mg/L)		pH	Maximum Temperature (Deg. C)
		Minimum	Daily Ave.		
IV	Mountainous Zone Waters	4.0	5.0	6-9	31

As shown in Figure 3-4, temperature field values are in compliance with the numeric criteria for Class IV waters at all monitoring stations in both the impaired segment and upstream of the biological impairment. The field pH values are presented in Figure 3-5. The data indicates that the pH values are generally in compliance with class IV criteria for the majority of the time, except for a brief period between January and May 2001. However, this pH drop could not be clearly explained based on the available data and information. Figure 3-6 shows that the field dissolved oxygen concentrations are generally in compliance with established standards; although one violation of the daily average dissolved oxygen standard occurred at station 2JKS018.68.

Figure 3-4: Field Temperature at Jackson River Monitoring Stations

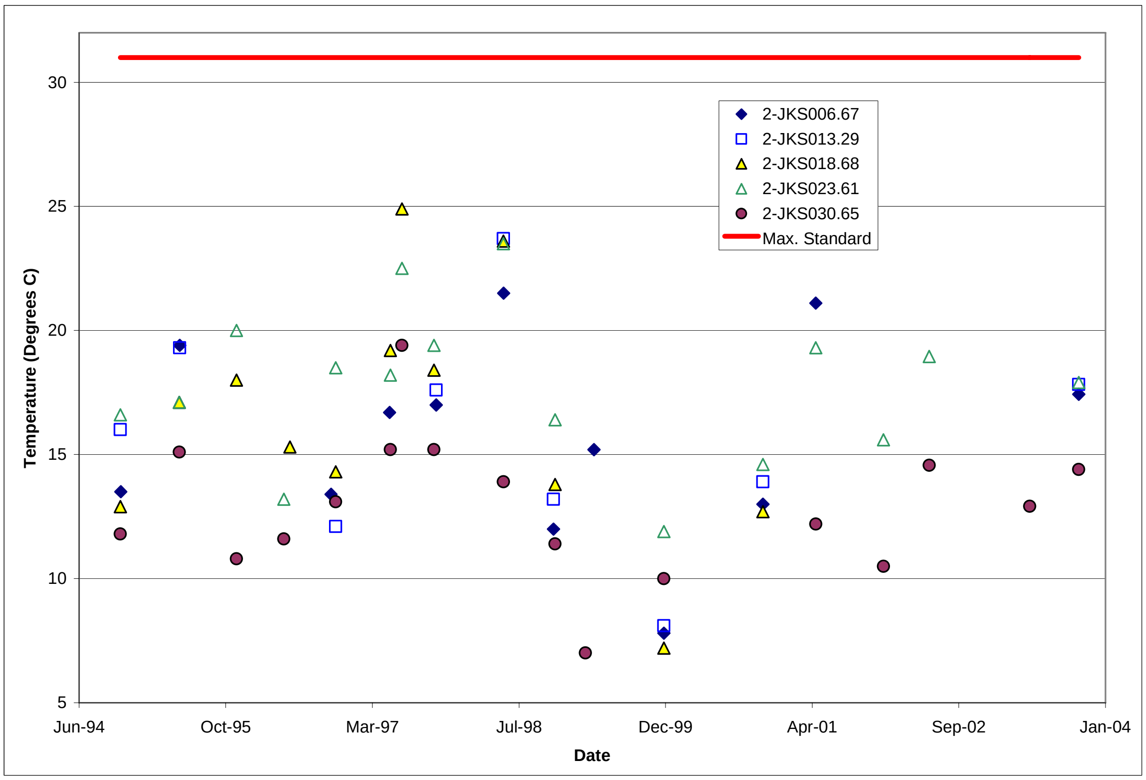


Figure 3-5: Field pH Values at Jackson River Monitoring Stations

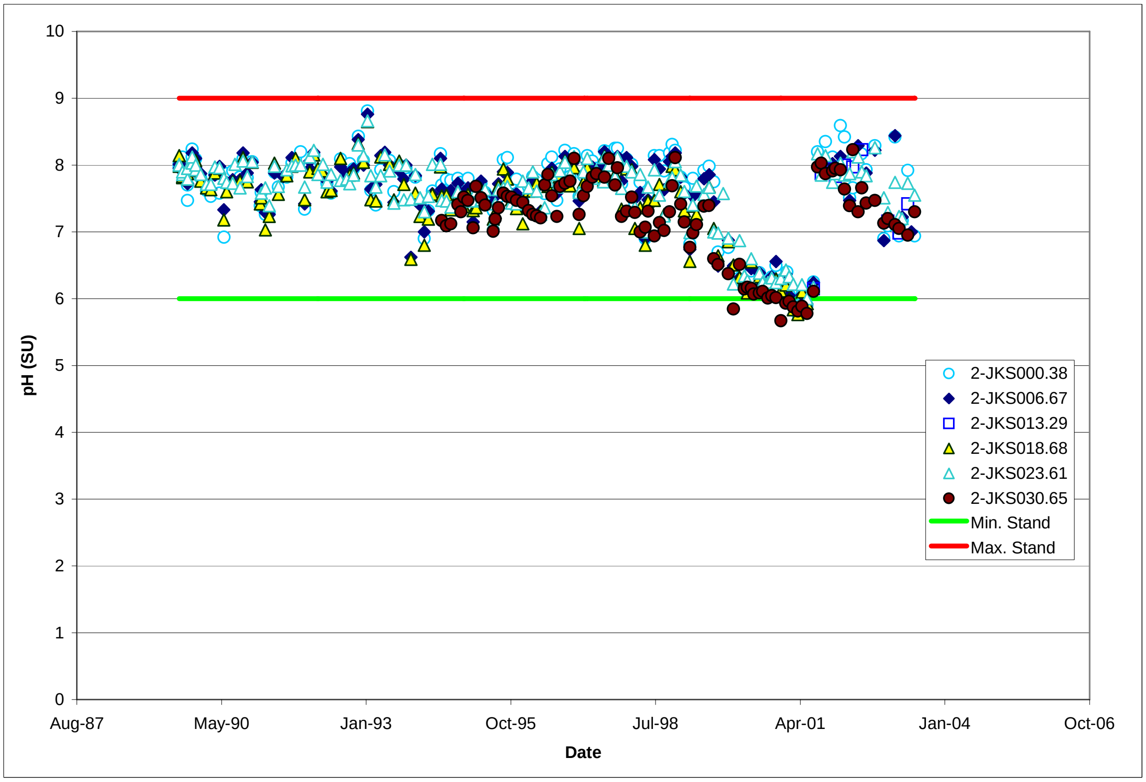
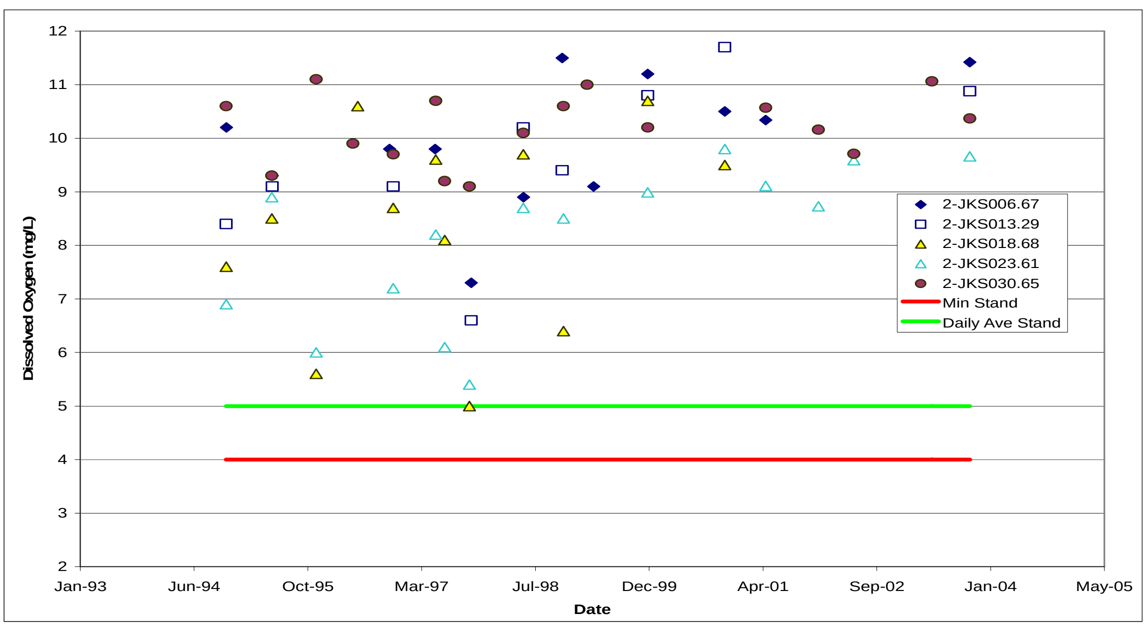
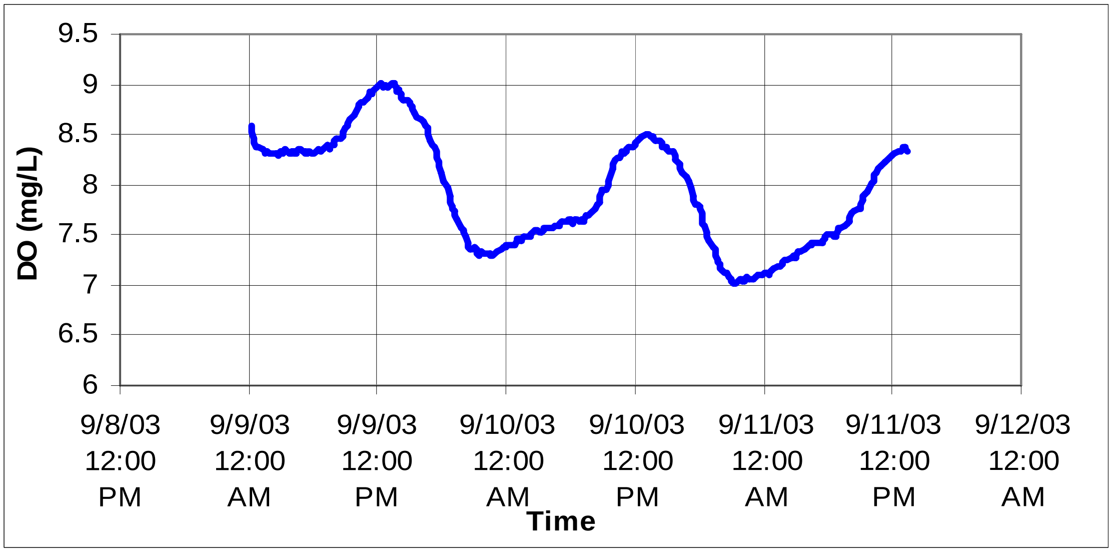


Figure 3-6: Field Dissolved Oxygen Concentrations



In addition to the field DO data shown in Figure 3-6, the VADEQ performed diurnal continuous DO monitoring during the fall season at locations on the Jackson River. The objective of the continuous DO monitoring was to assess and identify any DO violations during the evening and night periods and compare the DO diurnal variations on the Jackson to the natural variations on a reference stream outside the Jackson River impaired segment. The reference station selected is located in Tom's Creek, a tributary within the Jackson River ecoregion. Figure 3-7 depicts the 15-minute diurnal dissolved oxygen in Tom's Creek recorded between September 9, 2003 and September 11, 2003.

Figure 3-7: Tom's Creek Diurnal DO Levels - Sept. 9 to Sept.11 2003

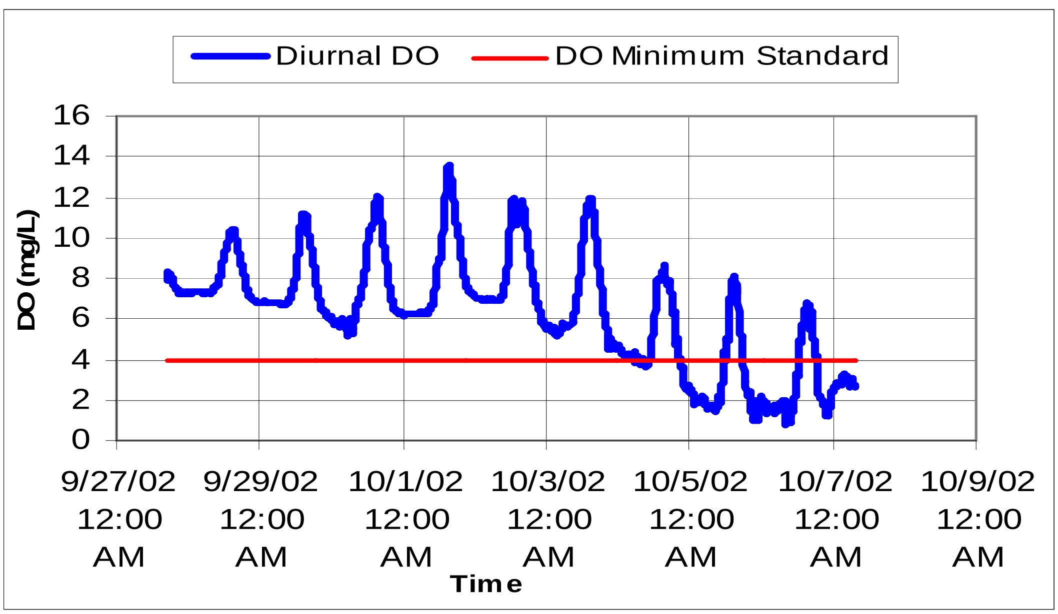


The continuous dissolved oxygen data within Tom's Creek show a moderate diurnal variation of 2 mg/l with a minimum DO of 7 mg/L, depicting the oxygen levels within a natural and unaffected stream system. The diurnal dissolved oxygen swings within Tom's Creek are included in this report as a depiction of the oxygen levels within a natural stream system and are not used to define or derive an endpoint to develop the TMDL for the Jackson River.

These natural DO variations are compared to the diurnal data recorded on the impaired segment of the Jackson River. In fact, 15-minute diurnal dissolved oxygen data were collected on the Jackson River between September 27 and October 7 2002, October 29 and November 1 2004, and between October 3 and October 5 2005. These sampling periods were selected in order to quantify oxygen conditions in the Jackson River under low flow, effluent dominated conditions.

Dissolved oxygen measurements collected during the period of September 27 to October 7 2002, shown in Figure 3-8, violated the minimum dissolved oxygen standard on numerous occasions, especially throughout the 7-day period spanning between October 1 and October 7 2002. The lowest recorded diurnal dissolved oxygen concentration during this period was 0.74 mg/L on October 6, 2002 at 8:30am. In addition, the data show dissolved oxygen fluctuations of over 7 mg/L in a 24-hour time period, indicating the possibility that eutrophic conditions were present in the river.

Figure 3-8: Jackson River Diurnal Dissolved Oxygen – September 27 - October 7, 2002



The diurnal DO data recorded during the period of October 29 to November 1 2004 do not violate in stream dissolved oxygen standards. Figure 3-9, shows that the DO levels are above the minimum DO standard of 4 mg/L and never fell below 4 mg/L.

Figure 3-9: Jackson River Diurnal Dissolved Oxygen – October 29 – November 1, 2004

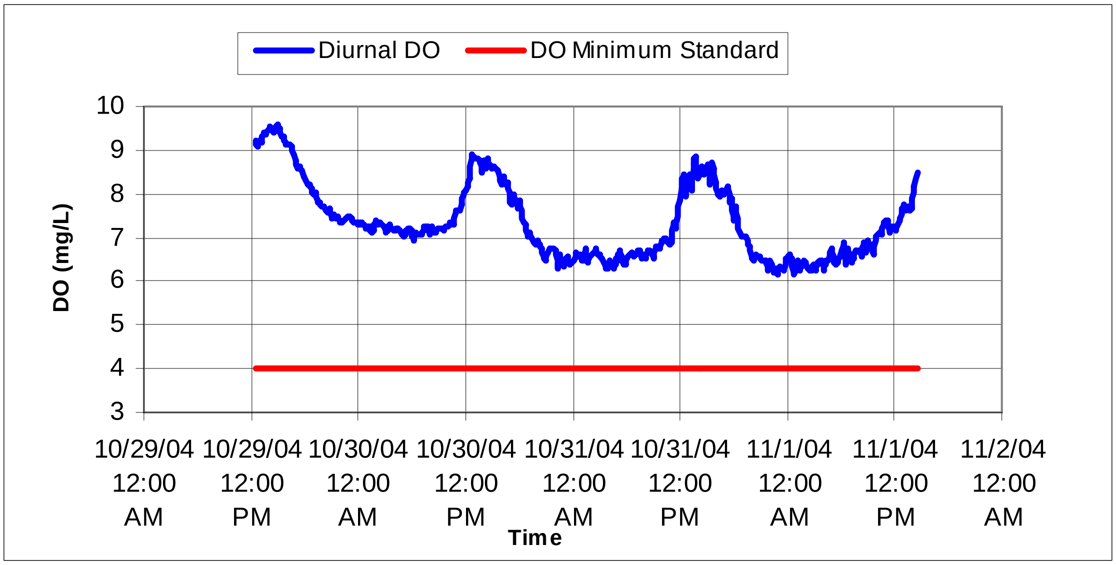
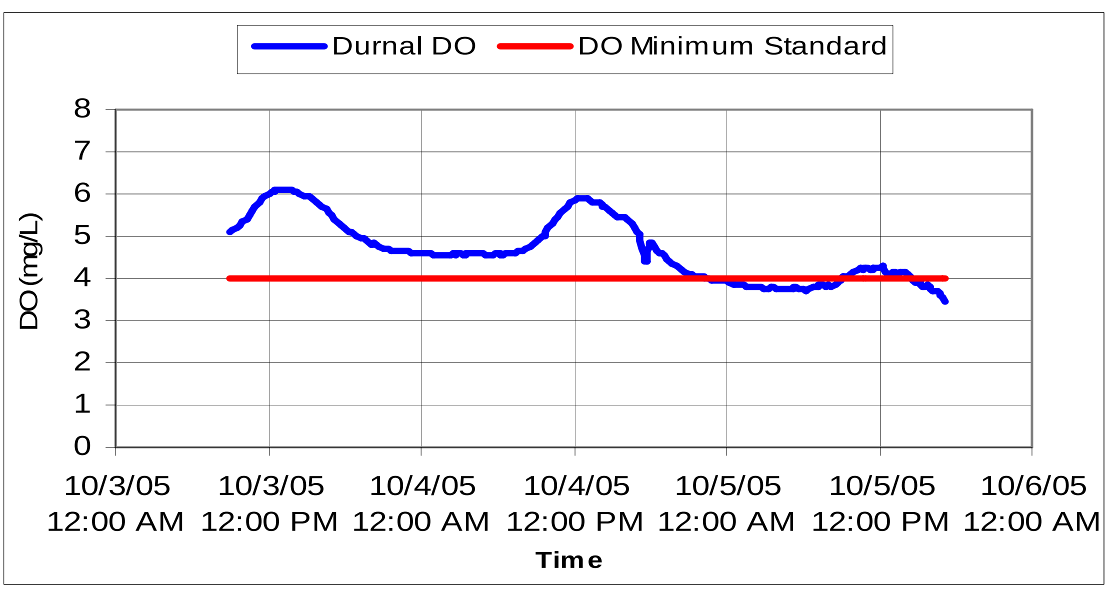


Figure 3-10 shows the results of the diurnal DO monitoring for the period spanning October 3 to October 5 2005. It indicates that the DO levels fell below the minimum DO standards on October 5, 2005.

Figure 3-10: Jackson River Diurnal Dissolved Oxygen - October 3 – October 5, 2005

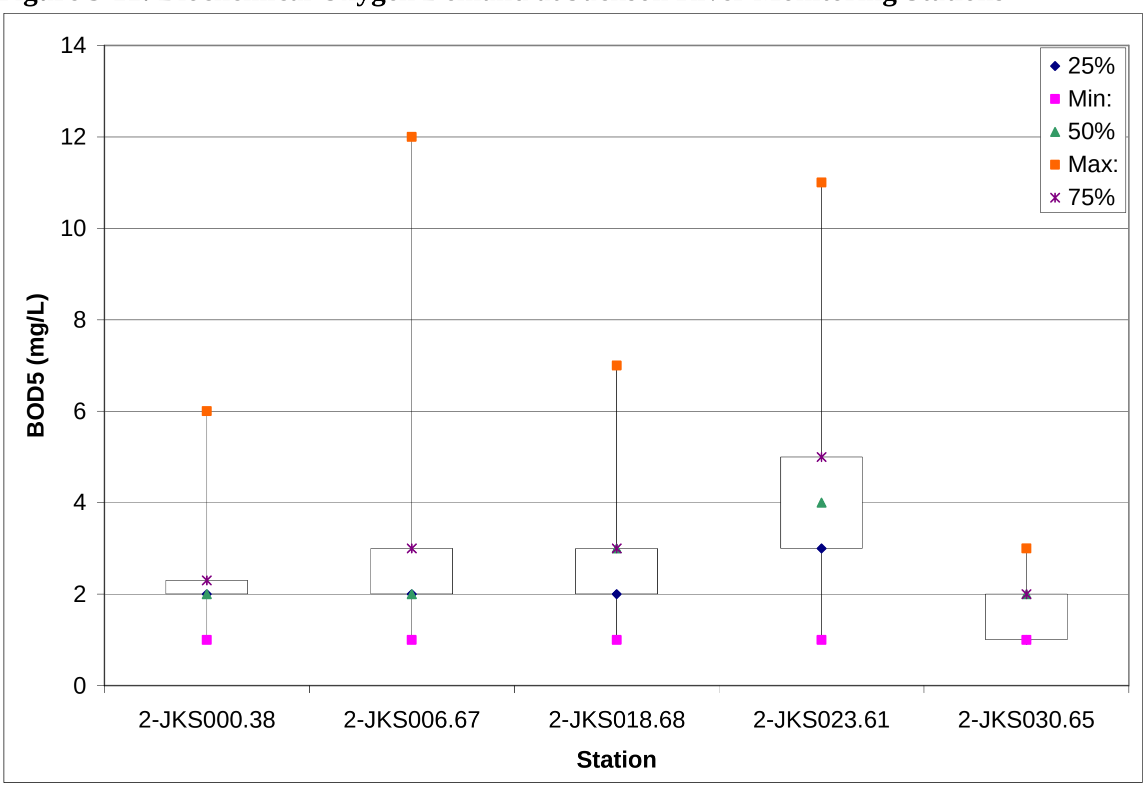


In summary, the analysis of the temperature and pH data indicates adequate levels in the Jackson River. However, the diurnal dissolved oxygen data shows numerous violations of the minimum DO standard of 4 mg/L indicating that eutrophic conditions might be present in the river. The diurnal DO monitoring data was mainly performed during low-flow conditions. Consequently, a detailed a analysis of the diurnal DO data and the low-flow conditions is presented in Section 3-4.

3.2.1.2 Analysis of Other Water Quality Parameters

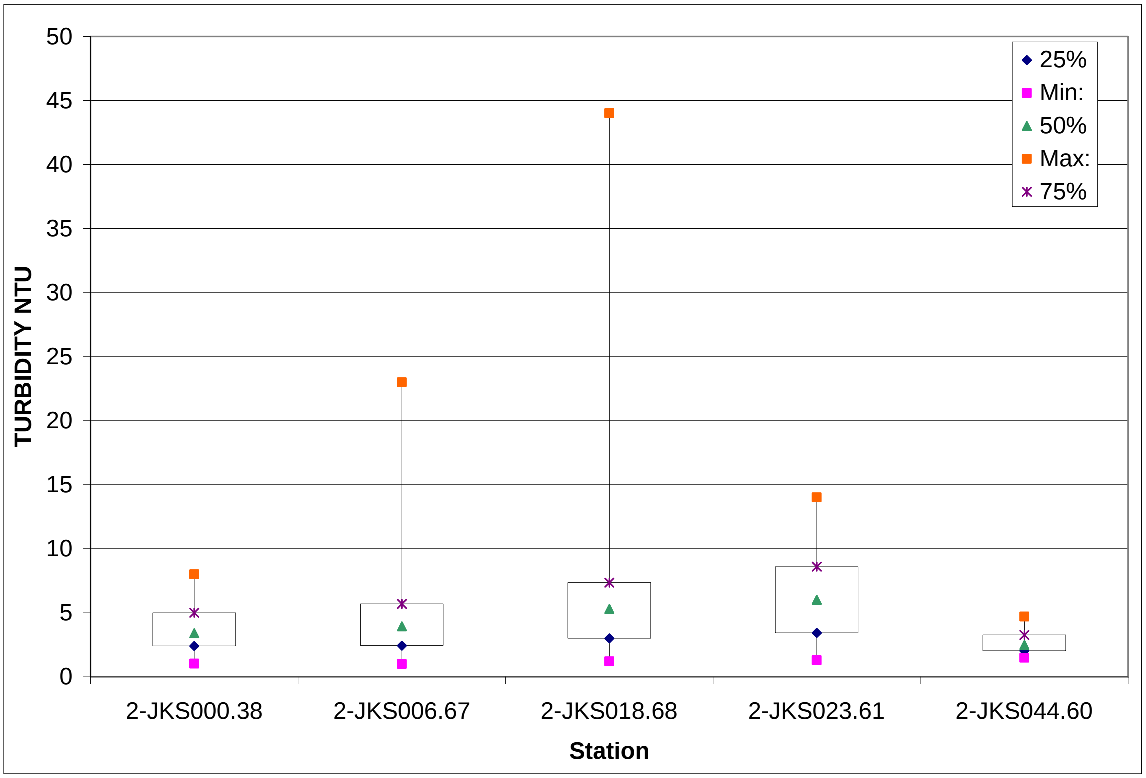
This section presents the analysis of other relevant instream water-quality parameters consisting of Biochemical Oxygen Demand (BOD), Turbidity, Nutrients, Chlorophyll a, and Fecal Coliform. Figure 3-11 indicates that instream Biochemical Oxygen Demand (BOD) concentrations were relatively low across all the stations in the Jackson River. It should be reminded that Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. For instance Station name 2JKS018.68 comprises of the abbreviated name *2JKS* and is at river mile *018.68*. Consequently, the most upstream is the reference station 2JKS030.65 and the down-stream stations are presented from right to left on the X-axis, with decreasing river mile.

Figure 3-11: Biochemical Oxygen Demand at Jackson River Monitoring Stations



BOD data summary indicates that BOD concentrations range from 1 to 2 mg/L at the reference station, with BOD levels increasing slightly at station 2JKS023.61 (3 to 5 mg/L) and leveling off between 2 and 3 mg/L at all the other downstream stations. Figure 3-12 shows the turbidity values at various monitoring stations in the Jackson River. These values are generally low across all sites, but elevated concentrations were recorded on some occasions.

Figure 3-12: Turbidity at Jackson River Monitoring Stations



Electrical conductivity is often used as a surrogate measure of the concentration of total dissolved solids in water. High levels of conductivity were observed at several monitoring stations in the Jackson River. Figure 3-13 indicates that the conductivity levels at station 2JKS023.61 were 5 to 10 times higher than the conductivity level at the reference station (2-JKS030.65).

Figure 3-14 indicates that nitrogen concentrations increased slightly from the upstream to downstream stations. Ammonia concentrations shown in Figure 3-15 indicate that the level of ammonia in the Jackson River is low and the median values do not vary between the stations. On the other hand, phosphorous concentrations increased substantially after station 2JKS026.01 and remained elevated at the downstream stations (Figure 3-16).

Figure 3-13: Conductivity at Jackson River Monitoring Stations

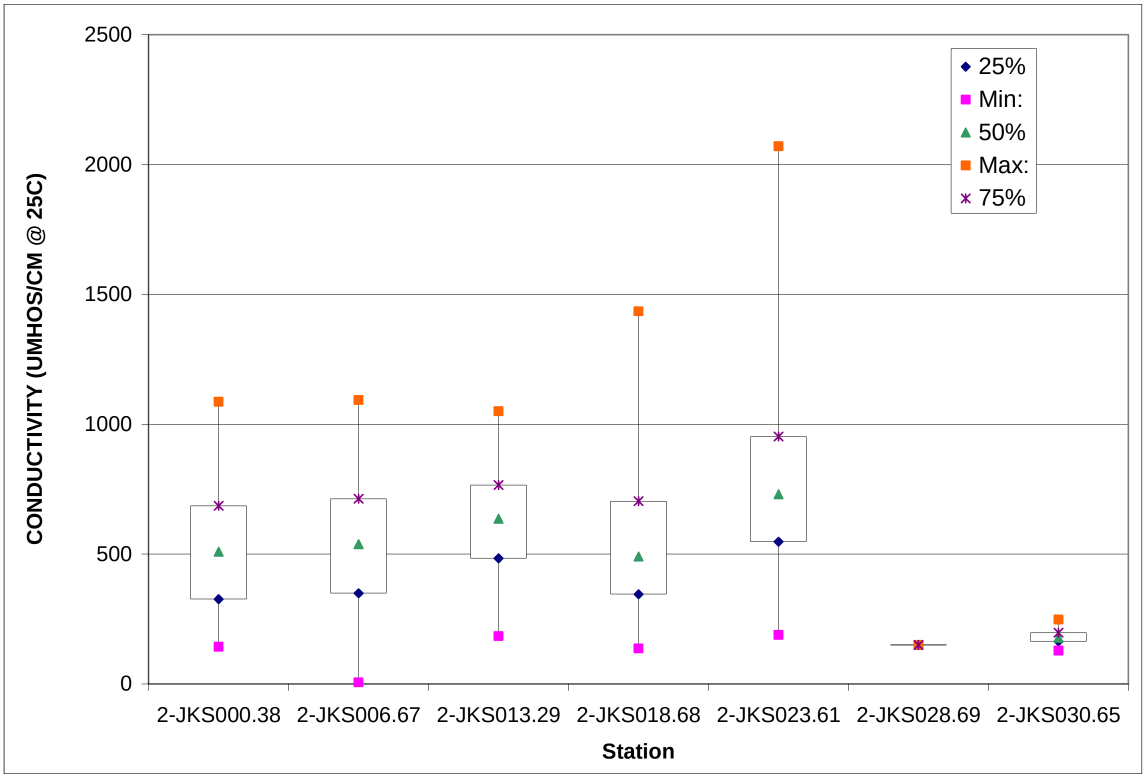


Figure 3-14: Total Nitrogen Concentrations at Jackson River Monitoring Stations

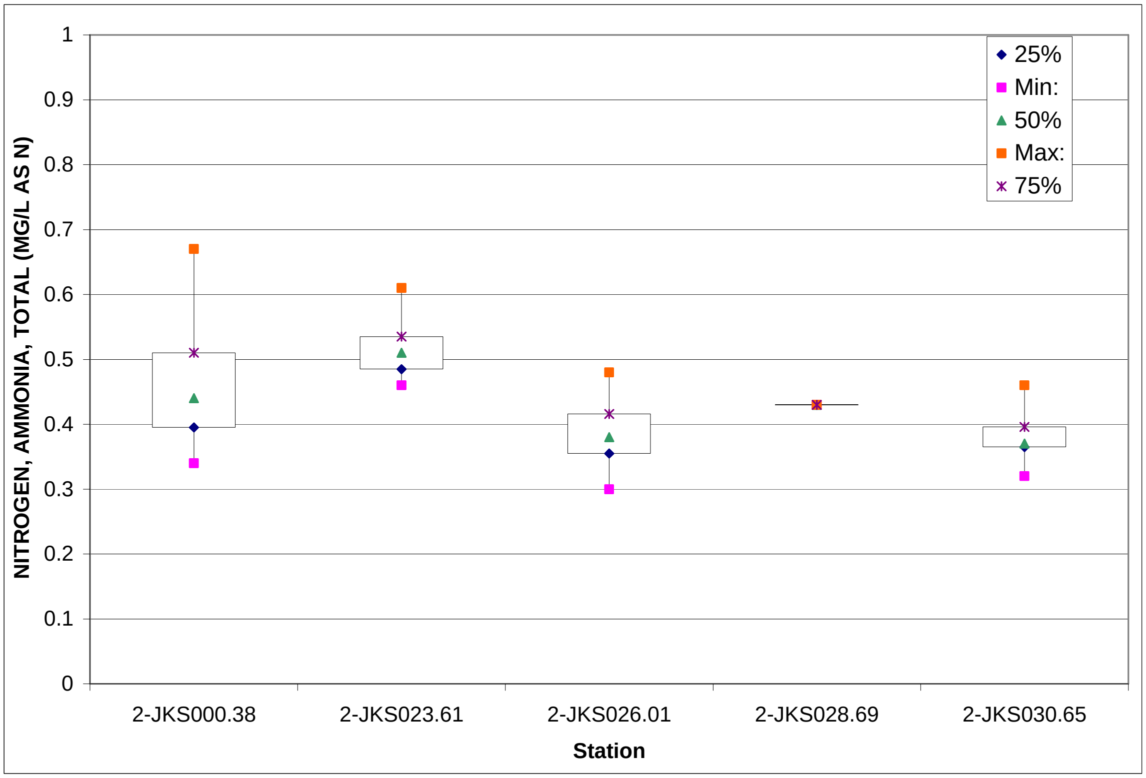


Figure 3-15: Ammonia Concentrations at Jackson River Monitoring Stations

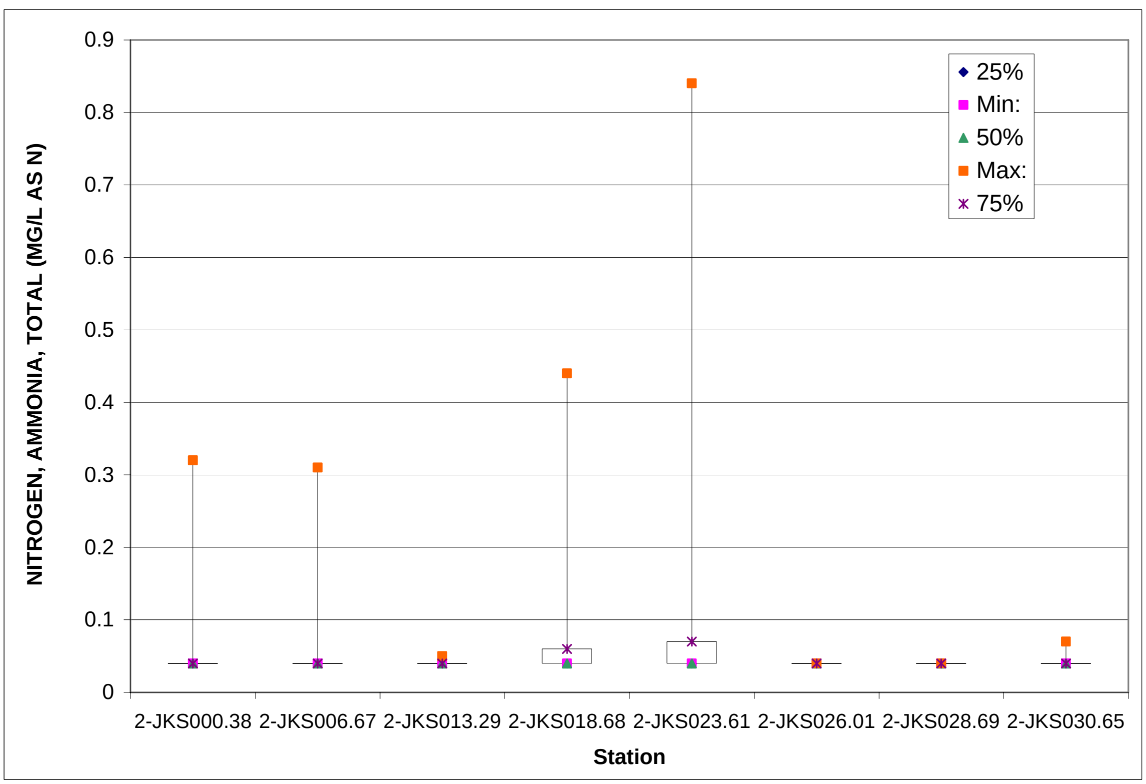
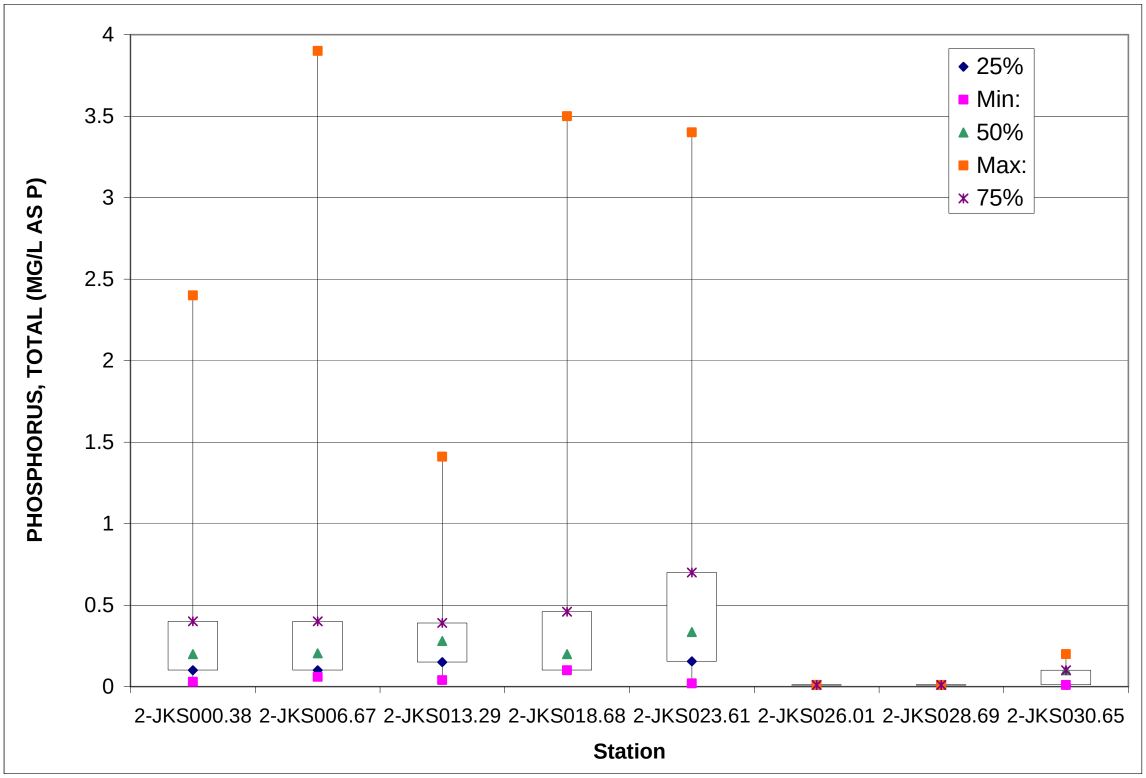


Figure 3-16: Total Phosphorus Concentrations at Jackson River Monitoring Stations



Observed chlorophyll a concentrations were elevated at stations downstream of reference station 2JKS030.65 (Figure 3-17). Fecal coliform concentrations were highest at station 2-JKS023.61 and were generally low at all other stations (Figure 3-18).

Figure 3-17: Phytoplankton Chlorophyll a Concentrations at Jackson River Monitoring Stations

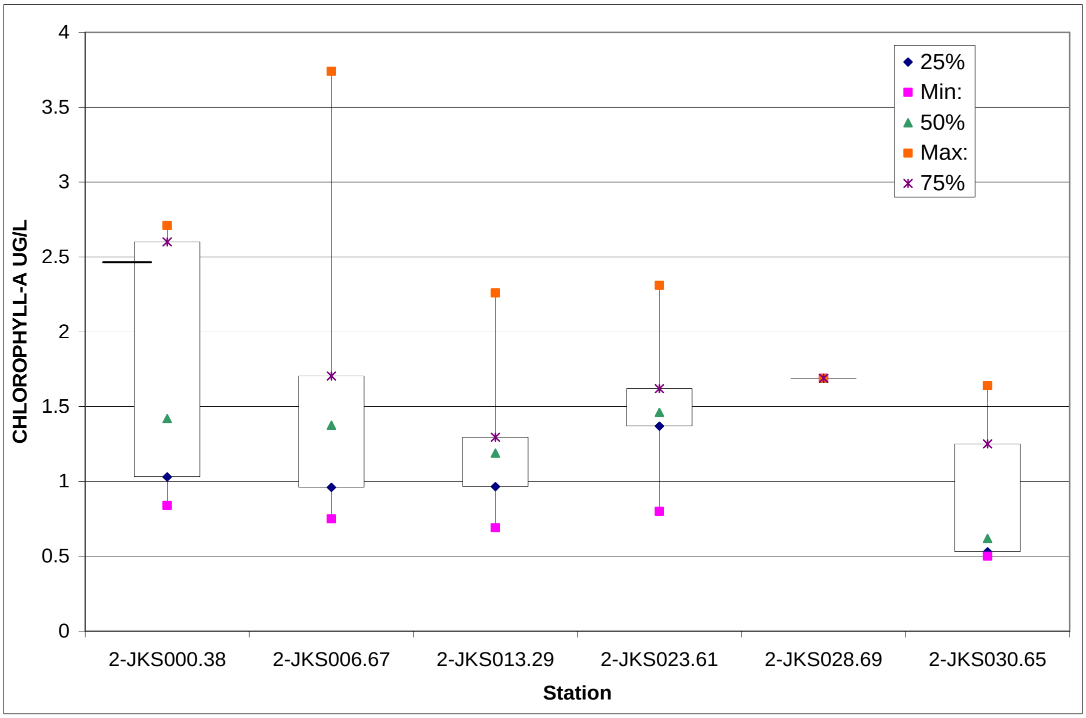
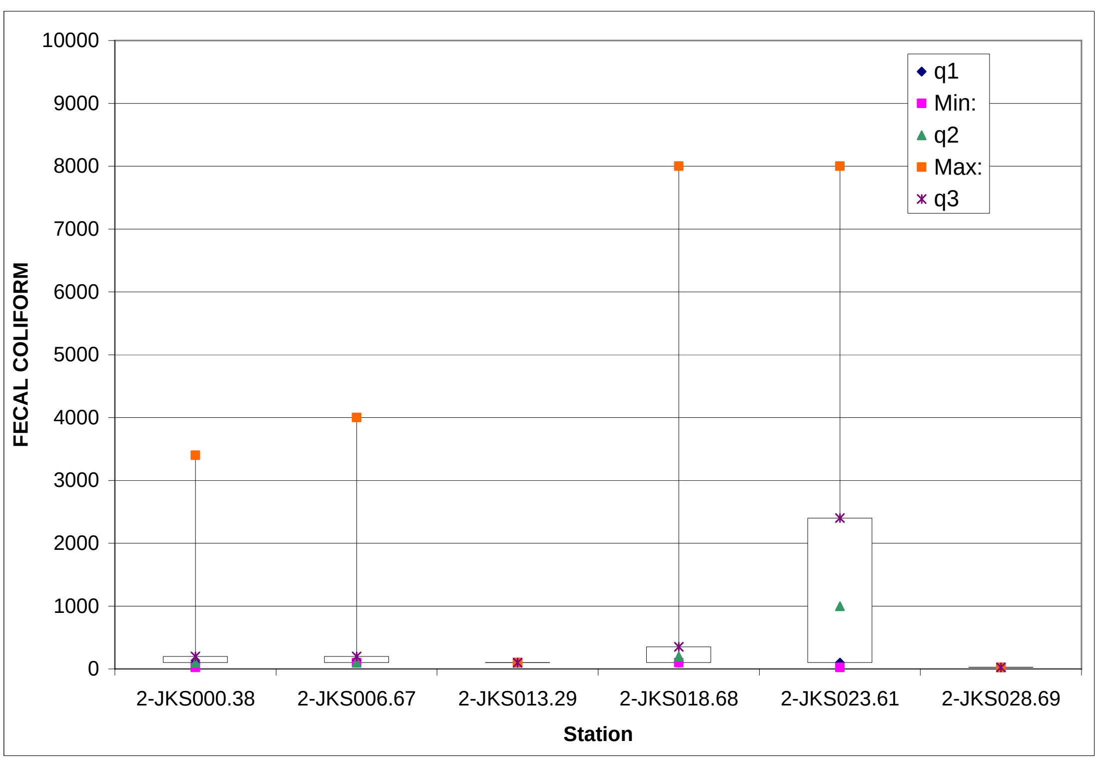


Figure 3-18: Fecal Coliform Concentrations at Jackson River Monitoring Stations



3.2.2 DEQ Metals Data

Both dissolved and sediment metals data were collected on the mainstem Jackson River. Dissolved metals data (Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, and Zinc) were collected at four stations on the impaired segment, stations 2JKS000.38, 2JKS006.67, 2JKS0018.86, and 2JKS0023.61 (Table 3-8). Sampling was conducted once in March 1990, and again in June 1992. As noted in Table 3-8, the criteria for many metals parameters are expressed as a function of total hardness as calcium carbonate and the Water Effect Ratio (WER), a measure of biological availability. In these instances, criteria were calculated using the average observed hardness of 137 mg/L as $CaCO_3$ and a WER of one. As indicated in Table 3-8, no dissolved metals parameters violated either the Virginia acute or chronic freshwater aquatic life criteria for dissolved metals.

Sediment metals data (Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, and Zinc) were collected at stations 2JKS00.0038, 2JKS006.67, 2JKS0018.86, 2JKS0023.61, 2JKS0028.65, 2JKS0030.61 (Table 3-9). Sediment metals data were collected between 35 and 42 occasions at each monitoring station from 1995 to 2004. There are currently no water quality standards established in Virginia for sediment metals; however, the 2004 DEQ assessment guidance memorandum (DEQ, 2004) establishes consensus based sediment screening values for use in determining aquatic life use support (Table 3-9). Sediment nickel values exceeded the 48,600 µg/kg screening value on several occasions at stations 2JKS000.38 and 2JKS006.67. In these instances, DEQ guidance states that “one or more exceedances of the sediment screening value results in a fully supporting but having observed effects status for aquatic life use support” (DEQ, 2004). All other observed sediment metals values were below the consensus based sediment screening values.

Table 3-8: Summary of Dissolved Metals Data Collected on Jackson River

Metals Parameter	River Mile	Date Collected	Total Number of Samples	Dissolved Freshwater Aquatic Life Criteria		Violation
				Acute (µg/L)	Chronic (µg/L)	
Arsenic	0.38, 6.67, 18.86, 23.61	1990,1992	9	340	150	No
Cadmium	0.38, 6.67, 18.86, 23.61	1990,1992	9	5.59[a]	1.42[a]	No
Chromium	0.38, 6.67, 18.86, 23.61	1990,1992	9	737.29[a]	95.89[a]	No
Copper	0.38, 6.67, 18.86, 23.61	1990,1992	9	18.06[a]	11.69[a]	No
Lead	0.38, 6.67, 18.86, 23.61	1990,1992	9	177.5[a]	20.08[a]	No
Mercury	0.38, 6.67, 18.86, 23.61	1990,1992	9	1.4	0.77	No
Nickel	0.38, 6.67, 18.86, 23.61	1990, 1992	9	237.94[a]	26.44[a]	No
Selenium	0.38, 6.67, 18.86, 23.61	1990, 1992	9	20	5	No
Zinc	0.38, 6.67, 18.86, 23.61	1990, 1992	9	152.90[a]	153.83[a]	No

a: Dissolved Criteria calculated based on an average observed hardness of 137 mg/L as $CaCO_3$ and Water Effect Ratio of 1

Table 3-9: Summary of Sediment Metals Data Collected on Jackson River

Metals Parameter	Collection Period	Total Number of Samples	River Mile	Freshwater Aquatic Life Support	
				Sediment Screening Value[a] (µg/kg)	Violation
Arsenic	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	33,000	No
Cadmium	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	4,980	No
Chromium	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	111,000	No
Copper	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	149,000	No
Lead	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.611	128,000	No
Mercury	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	1,060	No
Nickel	1995-2004	43	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	48,600	Yes
Selenium	1995-2004	39	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	NA	NA
Silver	1995-2004	35	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	NA	NA
Zinc	1995-2004	40	0.38, 6.67, 18.86, 23.61, 28.65, 30.61	459,000	No

a: Screening values specified in DEQ 2004 assessment guidance memorandum
NA: No value specified

3.2.3 DEQ Organics Monitoring

All available organics (Chlordane, DDD, DDE,, Endrin, Endosulfan, Heptachlor Epoxide, and total PCBs) data collected on the Jackson River by DEQ were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards and sediment screening values. Table 3-10 summarizes the monitored organics compounds. The majority of the available sediment organics data were below detection limits. Along the impaired segment of the Jackson River, no monitored dissolved organics parameters violated acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Additionally, no exceedances of the sediment screening values specified in the DEQ 2004 assessment guidance memorandum were observed.

Table 3-10: Summary of Organics Data Collected at Jackson River Monitoring Stations

Organics Parameter	Collection Period	River Mile	Number Dissolved Samples	Number Sediment Samples	Freshwater Aquatic Life Support			Number Acute/ Chronic Violations	Number Screening Value Violations
					Acute Dissolved Criteria (µg/L)	Chronic Dissolved Criteria (µg/L)	Sediment Screening Value[a] (µg/kg)		
Chlordane	1992-2000	0.38, 6.67, 18.86, 23.61, 30.65	None	42	2.4	0.0043	17.6	NA	0
DDD	1992-2000	0.38, 6.67, 18.86, 23.61, 30.65	None	42	NA	NA	28	NA	0
DDE	1992-2000	0.38, 6.67, 18.86, 23.61, 30.65	None	42	NA	NA	31.3	NA	0
Endrin	1992-2000	0.38, 6.67, 18.86, 23.61, 30.65	1	42	0.086	0.036	207	0	0
Endosulfan	2004	28.69	None	1	0.22	0.056	NA	0	NA
Heptachlor Epoxide	1992-2000	0.38, 6.67, 18.86, 23.61, 30.65	1	42	0.52	0.0038	16	0	0
PCBs, total	1995-2000	0.38, 6.67, 18.86, 23.61, 30.65	None	42	NA	NA	676	NA	0

a: Screening values specified in DEQ 2004 assessment guidance memorandum
NA: No criteria or value specified

3.2.4 DEQ Toxicity Testing

Toxicity testing was performed on water samples collected from the Jackson River by DEQ on May 2, 4, and 6, 2005 at stations 2JKS006.67 and 2JKS023.61. The EPA Region 3 laboratory in Wheeling, West Virginia performed acute and chronic toxicity testing on samples using fathead minnows (Pimephales promelas) and water fleas (Ceriodaphnia dubia) as test organisms.

Test results indicated that Ceriodaphnia mortality and reproduction in the Jackson River water samples were not statistically different than mortality and reproduction in the control samples, thus indicating that there were no toxic water column effects to Ceriodaphnia in the Jackson River samples. Fathead minnow growth in the Jackson River water samples was statistically different from growth in the control samples. Fathead minnow survival in samples collected at both station 2JKS006.67 and station 2JKS023.61 did significantly vary from minnow survival in the control samples. The ranges of minnow survival in samples collected at station 2JKS006.67 were between 10% to 80% and were statistically different from the laboratory control. Ranges of fathead minnow survival in samples collected at station 2JKS023.61 was between 30% to 60%, which was statistically different from the laboratory control. However, this result is inconsistent with previous toxicity tests showing that Ceriodaphnia are more sensitive than the fathead minnow. The EPA Region 3 laboratory in Wheeling indicated that in their professional judgment, these results “were probably biologically significant”, and that it was necessary to compare the observed toxicity testing results with other water quality data collected at these sites to determine the presence of toxicity.

Levels of ammonia, toxic to aquatic organisms in high concentrations, were low across all monitoring stations (Figure 3-14), suggesting that ammonia is not adversely impacting benthic invertebrates in the biologically impaired segment of the Jackson River

3.2.5 MeadWestvaco Water Quality Data

The MeadWestvaco Packaging Resource Group is the largest permitted discharger on the mainstem Jackson River. As part of the effort to improve water quality conditions in the river, MeadWestvaco has expended significant resources to support the collection of environmental monitoring data on the Jackson River. These data are presented below and divided into the following categories: benthic invertebrate monitoring data; instream water-quality data; effluent metals data; and periphyton data.

3.2.5.1 Benthic Invertebrate Monitoring Data

MeadWestvaco has sponsored or conducted over 24 biological studies of the Jackson River, beginning in 1951. The most recent study was conducted in 1998, and published in February 1999. Field work was conducted in the early summer, fall and early winter of 1998 at two reference sites and eight sites downstream of the MeadWestvaco facility (Environmental and Analytical Services, 1999). Biological monitoring stations 1-2 are the two reference sites located above the MeadWestvaco plant; stations 3-7 are located downstream of the facility (Table 3-11). These stations correspond roughly to the DEQ biological monitoring stations. The total area assessed in the biological monitoring survey encompassed over 50 miles of the Jackson River. Collection of benthic macroinvertebrates was conducted using natural and artificial substrate invertebrate sampling methods. Data analysis was conducted using the USEPA Level III Biological Condition Index (BCI) Score. Biological monitoring sampling results for natural and artificial substrates are summarized in Tables 3-12 and 3-13, respectively. Note that artificial substrate sampling was conducted only at stations 1, 2, 3, 4, and 6 on the Jackson River.

Table 3-11: Location of MeadWestvaco Biological Monitoring Stations

Biological Monitoring Station	River Mile	Site Description
1 (Reference Site)	29.4	Clearwater Park
2 (Reference Site)	25.3	Rivermont
3	23.6	Playground
4	20.8	Upstream of AET Facility
5	12.9	ValRidRd Cave
6	6.6	BLC College
7	0.5	Iron Gate

Table 3-12: Summary of MeadWestvaco Biological Monitoring Results (Natural Substrate)

Collection Period	Reference Score (Sites 1 and 2)	Station Number									
		3		4		5		6		7	
		BCI Score	Assessment	BCI Score	Assessment	BCI Score	Assessment	BCI Score	Assessment	BCI Score	Assessment
Early Summer	40	30	MOD	70	SLT	60	SLT	75	SLT	75	SLT
Fall	38	42	MOD	63	SLT	68	SLT	47	MOD	79	SLT
Early Winter	40	25	MOD	30	MOD	70	SLT	60	SLT	60	SLT

MOD= moderate impairment, SLT= slight impairment

Table 3-13: Summary of MeadWestvaco Biological Monitoring Results (Artificial Substrate)

Collection Period	Reference Score (Sites 1 and 2)	Station Number					
		3		4		6	
		BCI Score	Assessment	BCI Score	Assessment	BCI Score	Assessment
Early Summer	40	40	MOD	60	SLT	75	SLT
Fall	44	41	MOD	45	MOD	54	SLT
Early Winter	44	18	SEV	41	MOD	45	MOD

MOD= moderate impairment, SLT= slight impairment, SEV= severe impairment

3.2.5.2 Instream Water Quality Data

Instream water quality monitoring data was collected by MeadWestvaco at several stations along the Jackson River. Total and volatile suspended solids data collected in 2001 from May to November are summarized in Table 3-14. Nutrient data, which was collected from 2000 to 2002 and includes ammonia, nitrite, nitrate-nitrite, total dissolved nitrogen, phosphate, and total dissolved phosphorus, are summarized in Table 3-15. In both tables, monitoring stations are presented in order from upstream to downstream.

Total suspended solids concentrations measured in the Jackson River were, on average, low. Similarly, average volatile suspended solids concentrations were also low across monitoring stations.

Nutrient concentrations varied widely by station. Phosphorus concentrations were generally low from the Gathright Dam down to the MeadWestvaco facility. At the Mill Bridge station, immediately downstream of MeadWestvaco, average observed phosphate and total dissolved phosphorus concentrations were significantly higher than those observed immediately above the plant. Average observed phosphorus concentrations in the Jackson River generally remained constant moving downstream until the Covington City STP station, at which another spike in phosphorus concentrations was observed. Downstream of the Covington City STP, observed instream phosphorus concentrations remained fairly constant moving to the most downstream monitoring station at Clifton Forge.

Observed nitrogen concentrations were generally constant across sites, but were elevated at several monitoring stations. In particular, average observed nitrate-nitrite and total dissolved nitrogen concentrations at the Covington City STP and Hot Springs Treatment Plant stations were elevated. Average nitrate-nitrite and total dissolved nitrogen concentrations exceeded 10 mg/L at the Covington City STP station. Ammonia and nitrite concentrations were low across all monitoring stations. Average nutrient concentrations on tributaries flowing into the mainstem Jackson River were low, indicating that these tributaries were not significant sources of nitrogen and phosphorus loading to the impaired segment.

Table 3-14: Average Total and Volatile Suspended Solids Collected from May-Nov. 2001

Station	River Mile from MeadWestvaco Plant	Average Total Suspended Solids (mg/L)	Average Volatile Suspended Solids (mg/L)
Clearwater Bridge	-4.4	2.39	0.93
City Filtration Plant	-1.2	1.90	0.79
Mill Dam	0	3.72	1.11
Pedestrian Bridge	0.3	7.36	4.12
Dunlap Creek	0.5	2.24	0.84
Fudges Bridge	2	4.27	1.90
Hercules Bridge	3.7	6.36	2.96
Potts Creek	5.1	1.87	0.80
Idlewilde Bridge	5.9	7.47	2.31
Valley Ridge Bridge	12.6	12.49	2.30
Clifton Forge WWTP downstream	19.1	7.48	1.96

Table 3-15: Summary of Nutrient Data Collected on Jackson River by MeadWestvaco

Station Name	Collection Period	Count	NH4-N			$NO_2 + NO_3$			PO4-P			TDP			TDN			NO_2-N		
			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Gathright Dam	5/00-10/02	151	0.021	0.001	0.075	0.108	0.032	0.295	0.005	0.000	0.105	0.009	0.000	0.143	0.263	0.150	0.838	0.002	0.000	0.010
Hot Springs Treatment Plant	9/00-10/02	117	0.193	0.011	2.862	6.390	0.106	17.300	1.417	0.029	2.960	2.062	0.028	3.308	7.356	0.290	21.124	0.008	0.001	0.202
Natural Well	9/00-10/02	143	0.014	0.001	0.042	0.121	0.011	0.414	0.006	0.000	0.084	0.012	0.000	0.150	0.265	0.130	0.577	0.002	0.001	0.006
Post Chamber	8/00	1	0.042	0.042	0.042	0.288	0.288	0.288	0.318	0.318	0.318	0.500	0.500	0.500	0.610	0.610	0.610	-	-	-
Pre Chamber	9/00	1	0.031	0.031	0.031	0.274	0.274	0.274	0.331	0.331	0.331	0.505	0.505	0.505	0.630	0.630	0.630	-	-	-
City Filtration Plant	9/00-12/02	279	0.016	0.001	0.080	0.148	0.028	0.416	0.008	0.000	0.181	0.017	0.000	0.403	0.300	0.150	1.000	0.002	0.001	0.010
Mill Dam	8/00-10/02	451	0.019	0.003	0.136	0.141	0.027	0.499	0.011	0.000	0.261	0.020	0.000	0.391	0.307	0.140	1.414	0.003	0.001	0.039
Mill Bridge	10/00-1/02	106	0.157	0.003	1.602	0.091	0.025	0.202	0.364	0.020	1.610	0.498	0.049	2.303	0.583	0.330	2.330	0.009	0.002	0.057
Pedestrian Bridge	5/01- 1/02	367	0.084	0.003	1.189	0.116	0.014	0.436	0.396	0.008	3.600	0.534	0.021	5.048	0.539	0.230	1.870	0.004	0.002	0.054
Dunlap Creek	5/00- 1/02	297	0.017	0.003	0.131	0.142	0.000	1.580	0.013	0.000	0.345	0.025	0.000	0.500	0.264	0.060	1.031	0.002	0.00	0.028
City Library	10/00	4	0.098	0.075	0.116	0.135	0.131	0.145	0.509	0.468	0.531	0.509	0.468	0.597	0.545	0.510	0.570	0.014	0.013	0.015
Play Ground	10/00	4	0.063	0.050	0.491	0.135	0.125	0.140	0.453	0.381	0.491	0.544	0.470	0.578	0.525	0.500	0.550	0.018	0.017	0.019
Fudges Bridge	5/00-10/02	375	0.082	0.003	0.714	0.133	0.000	0.445	0.349	0.008	1.850	0.462	0.020	4.274	0.526	0.062	1.500	0.009	0.000	0.158
Industrial Park	5/00	4	0.035	0.018	0.060	0.140	0.117	0.177	0.437	0.401	0.469	0.476	0.456	0.496	0.455	0.400	0.550	0.020	0.014	0.028
Hercules Bridge	5/00-10/02	352	0.074	0.001	0.959	0.131	0.007	0.510	0.335	0.014	1.660	0.439	0.017	2.883	0.524	0.200	4.308	0.008	0.001	0.052
Potts Creek	5/00-10/02	278	0.014	0.000	0.056	0.056	0.000	0.286	0.019	0.000	0.748	0.037	0.000	1.634	0.196	0.035	0.553	0.002	0.000	0.031
Covington City STP	4/01-10/02	369	0.274	0.016	1.247	10.475	4.800	25.167	1.022	0.468	4.400	1.523	0.558	6.973	11.949	0.000	40.097	0.129	0.003	0.804
Idlewilde Bridge	5/00-10/02	401	0.065	0.003	0.948	0.168	0.013	0.635	0.317	0.015	1.630	0.409	0.028	1.839	0.528	0.140	1.740	0.011	0.002	0.139
Byrd Farm	10/00	4	0.013	0.007	0.019	0.122	0.105	0.141	0.270	0.151	0.371	0.276	0.166	0.369	0.438	0.410	0.500	0.010	0.007	0.012
Mallow Mall	5//00-10/02	351	0.072	0.003	0.570	0.200	0.036	0.686	0.299	0.017	1.830	0.400	0.031	2.524	0.571	0.260	1.680	0.014	0.001	0.244
Island Ford Bridge	10/00-10/02	100	0.053	0.003	0.556	0.189	0.019	0.742	0.235	0.014	0.872	0.292	0.030	0.900	0.490	0.240	1.710	0.020	0.002	0.250
Valley Ridge Bridge	5/00-10/02	370	0.040	0.000	0.513	0.173	0.007	0.619	0.282	0.015	2.010	0.381	0.028	2.850	0.513	0.150	1.537	0.008	0.000	0.069
Dabney LWB	9/00-10/00	10	0.016	0.008	0.023	0.213	0.022	0.386	0.539	0.143	1.470	1.037	0.191	1.780	0.439	0.260	0.590	0.018	0.002	0.037
Clifton Forge	9/00-10/02	451	0.034	0.003	0.404	0.136	0.003	0.721	0.257	0.006	1.850	0.346	0.031	1.810	0.442	0.190	1.400	0.009	0.000	0.205

3.2.5.3 Effluent Metals Data

The MeadWestvaco facility sampled its effluent for dissolved metals on two occasions; August 11, 2002 and December 5, 2002. The results of this sampling is presented in Table 3-16; as indicated by the table, almost all parameters were below analytical detection limits. No elevated concentrations of any of monitored parameters were observed in the MeadWestvaco effluent.

Table 3-16: MeadWestvaco Effluent Dissolved Metals Data

Dissolved Metals	Collection Method	Concentration (mg/L)	
		12/5/2002	8/11/2002
Antimony	EPA Method 200.7	< 0.1	< 0.1
Arsenic III	EPA Method 206.3	< 0.002	< 0.002
Arsenic	EPA Method 206.3	< 0.002	< 0.002
Barium	EPA Method 200.7	0.12	0.015
Cadmium	EPA Method 200.7	< 0.001	< 0.001
Chromium III	EPA Method 200.7	< 0.005	< 0.005
Chromium	EPA Method 200.7	< 0.005	< 0.005
Copper	EPA Method 200.7	< 0.005	< 0.005
Iron	EPA Method 200.7	0.41	0.11
Lead	EPA Method 200.7	< 0.005	< 0.005
Manganese	EPA Method 200.7	0.84	0.46
Mercury	EPA Method 245.1	< 0.0002	< 0.0002
Nickel	EPA Method 200.7	< 0.05	< 0.05
Selenium	SM 3114	0.002	< 0.001
Silver	EPA Method 200.7	< 0.02	< 0.02
Tin	EPA Method 200.7	< 0.05	< 0.05
Tributyltin	EPA Method 200.7	< 0.25	< 0.25
Zinc	EPA Method 200.7	< 0.02	< 0.02

3.2.5.4 Periphyton Data

Periphyton (i.e., attached benthic algae) data were also sampled at several stations upstream and downstream of the MeadWestvaco plant. Table 3-17 summarizes the results for periphyton ash-free dry mass (AFDM), chlorophyll A, and total rock area. Periphyton chlorophyll A concentrations increased at the Mill Dam and Mill Bridge stations, located in the immediate vicinity of the MeadWestvaco plant, as compared to concentrations above the facility. An additional spike in chlorophyll A concentrations was observed at the Playground, Skate Park, and Industrial Park stations, located immediately downstream of several additional point sources.

Table 3-17: Summary of MeadWestvaco Periphyton Data

Station	Collection Period	Count	AFDM (g/m^2)			Chlorophyll A (mg/m^2)			Total Rock Area (cm^2)		
			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
City Filtration Plant	5/01-10/02	229	12.32	0.00	89.68	56.57	0.00	555.40	286.72	43.1	1350.
Mill Dam	5/01-11/01	97	47.00	0.00	673.26	324.27	0.00	2393.29	308.12	57.9	1350.
Mill Bridge	8/00-9/01	67	38.69	0.00	134.74	330.84	0.00	604.20	178.68	0.00	604.
Play Ground	5/98-10/01	303	53.86	0.40	681.34	504.70	0.00	3627.22	240.72	8.30	1350.
Skate Park	7/01	5	60.90	26.4	100.17	492.43	214.	1411.00	171.14	84.2	319.5
Industrial Park	5/98-5/01	447	50.74	0.00	635.40	503.12	0.00	4432.70	203.67	16.9	1350.
Hercules Bridge	7/01	5	23.82	16.3	31.21	233.17	184.9	331.17	152.74	98.6	232.6
Potts Creek	7/01	5	29.90	14.6	51.28	276.69	69.66	494.95	140.76	82.3	226.9
Idlewilde Bridge	7/01-10/01	20	20.23	0.06	52.96	200.99	38.45	651.74	157.13	88.1	262.7
Byrd Farm	6/98-10/01	53.	25.23	0.08	323.32	249.95	14.22	1058.75	403.29	71.2	1350.
Mallow Mall	5/98-10/01	204	34.08	2.25	606.59	370.49	0.00	2193.76	239.04	28.1	1350.
Island Ford Bridge	7/01	1	24.71	24.71	24.71	89.11	89.11	89.11	309.00	309.0	309.
Valley Ridge Bridge	7/01-10/01	30	5.27	120.66	120.66	26.43	1389.02	1389.02	50.20	259.3	259.3
Dabney LWB	8/98-10/01	171	25.81	0.00	255.13	206.35	0.00	1259.88	219.61	32.0	1321.
Clifton Forge	7/01	10	17.61	10.44	37.14	87.26	39.60	203.49	128.16	51.2	224.5

3.2.6 Jackson River Periphyton Studies

Periphyton is typically the dominant form of algae present in lotic systems. High nitrogen and phosphorus concentrations can stimulate algal growth, which may result in eutrophic conditions, high organic loading, and decreased dissolved oxygen levels. To examine the relationships between periphyton growth, nutrient concentrations, and dissolved oxygen levels in the Jackson River, MeadWestvaco commissioned several studies between 1999 and 2001 that examined the metabolism, effects of water velocity, and biomass of the periphyton community along the impaired segment of the Jackson River. These studies are briefly summarized below; for additional information please reference the primary report as cited.

3.2.6.1 Periphyton Community Metabolism Studies

To quantify and gain a better understanding of the role of periphyton metabolism on ecosystem function in the Jackson River, two studies entitled *Periphyton Community Metabolism in the Jackson River near the Westvaco Mill Site, Covington VA* were commissioned by MeadWestvaco and conducted by Thomas Bott of the Stroud Water Research Center (Bott, 1998; 1999). The purpose of these studies was to investigate the origin of the sporadic dissolved oxygen levels in the Jackson River and to determine if low dissolved oxygen levels in the fall were affected by accumulated periphyton biomass growth and development earlier in the year. Rates of primary productivity and community respiration, as well as environmental variables such as nutrients, light, and temperature, were measured. Results illustrated that the periphyton community is an important factor affecting the oxygen balance in the Jackson River. Additionally, the studies indicated that the MeadWestvaco facility does impact the periphyton community via nutrients discharged from the plant, and that accumulation of periphyton biomass in the late spring does impact the low dissolved oxygen levels observed in the Jackson River in the fall (Bott, 1998; 1999).

3.2.6.2 Water Velocity Impacts on Periphyton Biomass and Nutrient Uptake

To quantify the effect of flow regime on periphyton biomass and nutrient uptake in the Jackson River, a study entitled *The Effects of Water Velocity on Jackson River Periphyton Biomass and Nutrient Uptake* was commissioned by MeadWestvaco and conducted by Thomas Bott and J. Denis Newbold of the Stroud Water Research Center (Bott and Newbold, 2000). This study, conducted in November 1999, examined the effects of water velocity on periphyton community biomass, as well as the nutrient exchange and oxygen uptake between the water column and periphyton. Results indicated that increased flow velocity resulted in significant scour of periphyton in the Jackson River. Nutrient uptake results indicated variable uptake rates for different periphyton communities; however, all communities took up significant phosphorus (Bott and Newbold 2000).

3.2.6.3 Algal Biomass Community Composition Studies

In order to quantify algal biomass and spatial changes in algal community composition in the Jackson River, several studies were commissioned by MeadWestvaco and conducted by the Patrick Center for Environmental Research in Philadelphia, PA (Patrick Center for Environmental Research, 1998; 2000; 2001). Results indicated that the lowest algal biomass values occurred upstream of the MeadWestvaco facility, and was highest downstream of the facility at the Industrial Park site. Algal community composition shifted from diatom dominated communities immediately downstream of MeadWestvaco at the City Playground site to Cladophora dominated communities at the Industrial Park site further downstream (Patrick Center for Environmental Research, 2000). Results indicated that nitrogen may be the limiting nutrient at some downstream sites under certain conditions. Additionally, decreases in algal biomass observed following significant rain events indicated that excessive algal growth was related to low flow conditions under which point source effluent comprises the majority of flow in the river. As mentioned previously, Section 3-4 presents a statistical analysis on the low-flow combined with the continuous diurnal DO monitoring in the Jackson River.

3.3 Discharge Monitoring Reports

This section presents and analyzes the Discharge Monitoring Reports (DMR) for each of the 15 permitted facilities discharging into the Jackson River. This section also include information in Whole Effluent Toxicity (WET) and Nutrients Monitoring Records (NMR) collected at Covington City STP.

Table 3-18 shows the facilities in the Jackson River watershed currently online with a discharge design flow greater than 1 million gallons per day (MGD) specified in their NPDES permits. Several of the monitored parameters discharged from the main outfalls of these facilities are displayed in Figures 3-20 through 3-27.

Table 3-18: Facilities with a Discharge Design Flow Greater than 1 MGD

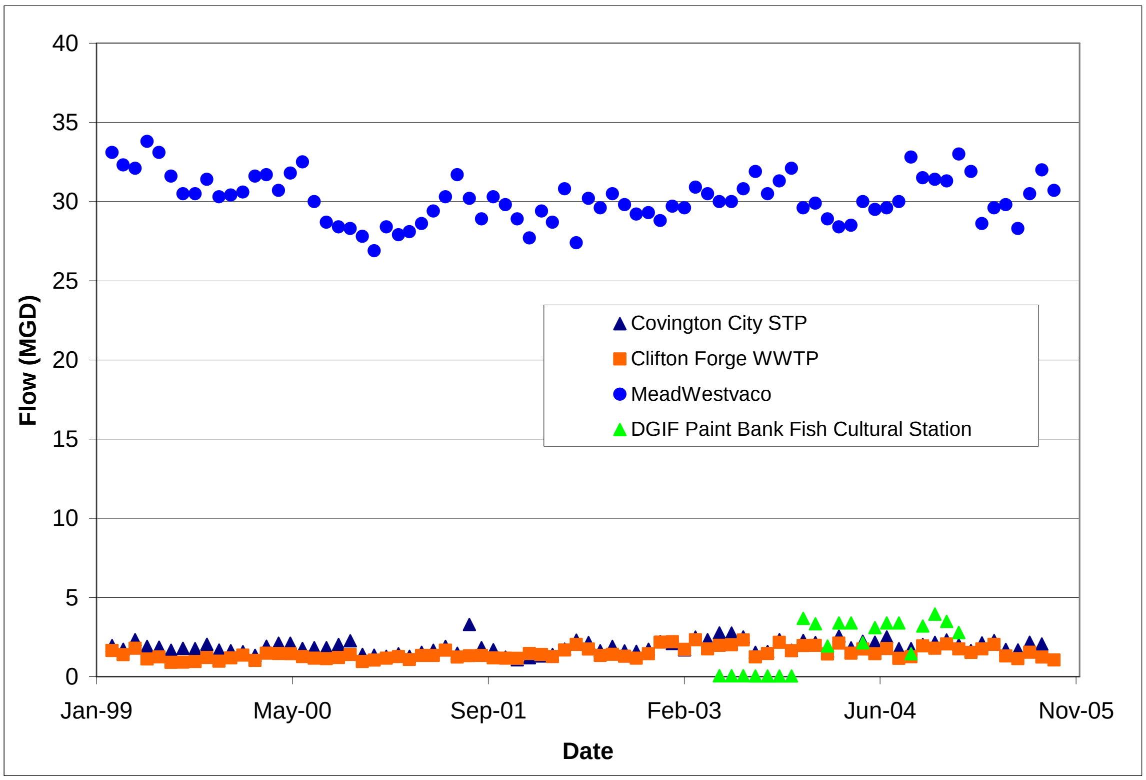
Permit Number	Facility Name (main outfall #)	Facility Type	Design Flow (MGD)[1]	Receiving Waterbody	Status
VA0022772	Clifton Forge City STP (1)	Municipal	2.0	Jackson River	Active
VA0025542	Covington City STP (1)	Municipal	3.0	Jackson River	Active
VA0091324	DGIF Paint Bank Fish Cultural Station (1)	Industrial	2.9	Paint Bank Branch	Active
VA0003646	MeadWestvaco Packaging Resource Group (3)	Industrial	32.9	Jackson River	Active
VA0090671	Alleghany Co - Lower Jackson River WWTP	Municipal	2.0	Jackson River	Inactive

1: Million Gallons per Day

Permit limits for all 15 permitted facilities are presented in Appendix B; DMR data for all 15 facilities are presented in Appendix C.

The discharge monitoring reports for each of the four major facilities with design flows above 1 MGD include monitoring data for several of the same parameters, including flow, BOD5, total suspended solids, and pH. Other parameters such as phosphorous, nitrogen, and ammonia were only monitored at MeadWestvaco, Clifton Forge WWTP, Covington City STP. Average flow discharge data for the facilities indicates that the MeadWestvaco facility discharges the largest effluent flow into the Jackson River impaired segment (Figure 3-19).

Figure 3-19: Flow Discharged from Facilities with a Design Flow Greater than 1 MGD



In general, the 15 permitted facilities discharged below their permitted limits for most of the constituents. A summary of permitted discharge limit violations at the 15 facilities between 1999 and 2005 is presented in Table 3-19. These violations include:

- Alleghany County Low Moor STP (Permit #: VA0027979), which has exceeded its permitted limits for BOD5, as well as Cl_2 concentrations.
- Applied Extrusion Technologies (Permit #: VA0003450), which has exceeded its permitted limits for BOD5 quantities, total suspended solids, and temperature.

- The Boys Home Inc STP (Permit #: VA0088544), which has exceeded its permitted limits for flow and total suspended solid quantities.

- The Clifton Forge City STP (Permit #: VA0006076), which has exceeded its permitted limits for flow and BOD5 concentrations.

- The Covington City STP (Permit #: VA0025542), which has exceeded its permitted limits for flow and total suspended solid quantities.

- CSX Transportation Inc (Permit #: VA0003344), which has exceeded its permitted limits for acute toxicity and petroleum hydrocarbon concentrations.

- DGIF Paint Bank Fish Cultural Station (Permit #: VA0091324), which has exceeded its permitted limits for total suspended solid concentrations and settable solids concentrations at five outfalls.

- The MeadWestvaco facility (Permit #: VA0003646), which has exceeded its permitted limit for BOD5 quantities.

- The Morris Hill STP (Permit #: VA0032115), which has exceeded its permitted limit for Cl_2 quantities.

- Spongedale Subdivision (Permit #: VA0088552), which has exceeded its permitted limits for total suspended solids and BOD5 concentrations.

- The VDOT I64 Rest Area - Alleghany County (Permit #: VA0075574), which has exceeded its permitted limits for flow, total suspended solids, and BOD5 concentrations.

Permit limits for all 15 facilities holding individual NPDES permits are presented in Appendix B; DMR data for all 15 facilities are presented in Appendix C.

Table 3-19: Exceedances of Permitted Discharge Limits for Facilities in the Jackson River Watershed

Permit No. (Outfall No.)	Facility Name	Parameter Description	First DMR Date	Last DMR Date	No. DMRs	DMR Reported Values				No. Exceedances of Permit Limits			
						Quantity		Concentration		Quantity		Concentration	
						Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
VA0027979 (1)	Alleghany Low Moor STP	BOD5	Feb-1999	Jan-2005	72	6.94	9.81	11.00	13.55	0	1	22	17
		Cl2, Total	Feb-1999	Jan-2005	47	-	-	0.96	2.80	-	-	0	12
VA0003450 (1)	Applied Extrusion Technologies	Water Temperature	Feb-1999	Jan-2005	56	-	-	-	18.9	-	-	-	1
VA0003450 (103)	Applied Extrusion Technologies	BOD5	Feb-1999	Jan-2005	47	0.82	0.82	6.07	6.07	3	1	-	-
		TSS	Feb-1999	Jan-2005	47	0.94	0.94	6.97	7.04	4	0	-	-
VA0088544 (1)	Boys Home Inc - STP	Flow	Feb-1999	Jan-2005	73	0.015	0.019	-	-	4	-	-	-
		TSS	Feb-1999	Jan-2005	74	1.23	1.23	21.64	21.64	2	0	0	0
VA0006076 (1)	Clifton Forge City STP	Flow	Feb-1999	Sept-2005	72	1.48	2.34	-	-	10	-	-	-
		BOD5	Feb-1999	Sept-2005	72	107.07	139.19	20.61	25.94	0	0	6	4
VA0025542 (1)	Covington City- STP	Flow	Feb-1999	Aug-2005	72	1.89	3.60	-	-	1	-	-	-
		TSS	Feb-1999	Aug-2005	72	26.58	44.00	2.79	4.48	-	1	-	-
VA0003344 (1)	CSX Transportation Inc	Acute Toxicity	Feb-1999	Feb- 2004	7	-	0.61	-	-	-	1	-	-
		Petroleum Hydrocarbons	Feb-1999	Oct-2004	28	-	-	3.49	3.72	-	-	2	-
VA0091324 (1)	DGIF Paint Bank Fish Cultural Station	TSS	May-2003	Jan- 2005	21	-	-	4	4	-	-	2	2
		Settable Solids	May-2003	Jan- 2005	21	-	-	0.17	0.17	-	-	3	0
VA0091324 (3)	DGIF Paint Bank Fish Cultural Station	TSS	May-2003	Jan- 2005	21	-	-	2.14	2.14	-	-	1	1
		Settable Solids	May-2003	Jan- 2005	21	-	-	0.16	0.16	-	-	2	0
VA0091324 (4)	DGIF Paint Bank Fish Cultural Station	TSS	May-2003	Jan- 2005	21	-	-	3.75	3.75	-	-	1	1
		Settable Solids	May-2003	Jan- 2005	6	-	-	0.23	0.23	-	-	2	0
VA0091324 (5)	DGIF Paint Bank Fish Cultural Station	TSS	May 2003	Nov 2004	7	-	-	5.4	5.4	-	-	1	1
		Settable Solids	May 2003	Nov 2004	7	-	-	0.25	0.25	-	-	2	0
VA0091324 (6)	DGIF Paint Bank Fish Cultural Station	TSS	May 2003	Nov 2004	7	-	-	5.2	5.2	-	-	1	1
		Settable Solids	May 2003	Nov 2004	7	-	-	0.2	0.2	-	-	1	0
VA0003646 (3)	MeadWestvaco Resource Packaging Group	BOD5	Jan 2003	Sept 2005	71	1935.33	3606.75	15.76	26.83	0	2	-	-
VA0032115 (1)	Morris Hill STP	Cl2, Inst. Max	Nov 1999	Jan 2005	60	-	-	1.72	1.85	-	-	1	-

Permit No. (Outfall No.)	Facility Name	Parameter Description	First DMR Date	Last DMR Date	No. DMRs	DMR Reported Values				No. Exceedances of Permit Limits			
						Quantity		Concentration		Quantity		Concentration	
						Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
VA0088552 (1)	Sponaugle Subdivision	TSS	Apr 2000	Oct 2004	13	0.77	0.79	21.31	21.31	1	1	1	1
		BOD5	Apr 2000	Oct 2004	13	0.64	0.64	30.62	30.62	-	-	3	2
VA0075574 (1)	VDOT I64 Rest Area - Alleghany County	Flow	Feb 1999	Feb 2003	46	0.004	0.006	-	-	1	1	-	-
		TSS	Feb 1999	Jan 2003	46	0.17	0.18	11.52	12.12	0	0	2	1
		BOD5	Feb 1999	Jan 2003	44	0.13	0.13	8.64	8.64	-	-	3	1

3.3.1 Whole Effluent Toxicity Sampling

Whole Effluent Toxicity (WET) monitoring data is part of the DMR and is presented in this section. CSX Transportation Inc, Mead Westvaco, and the City of Covington STP performed WET testing. Water samples were colleted from the discharge effluent of these facilities and then analyzed for toxicity.

MeadWestvaco collected WET monitoring data from effluent 003 between June 2001 and February 2002. The test series resulted in 10 valid sets of toxicity tests for use in reassessing the need of a WET effluent limit. The results from these tests illustrated that the monthly samples were not chronically toxic for the survival of C. dubia or P. promelas or the growth of P. promelas. Samples were chronically toxic for reproduction of the C. dubia with NOEC (highest concentration at which no observable effect occurred) values ranging from <33% to 76%. The conclusion made by DEQ (August 2003) based on this data was that under agency TMP guidance, the whole effluent did not violate the in-stream water-quality standard and therefore, no limit for WET is needed for this outfall.

The City of Covington STP collected WET monitoring data annually between April 1994 and June 2004 from Outfall 001. Annual acute and chronic toxicity testing both used 24-hour flow-proportioned samples. The acute tests, which are 48-hour static tests using Primephales promelas, showed the range of survival in 100% effluent with a LC_{50} (effluent concentration at which 50% of the test organisms die during the test) greater than 100 between 75% and 100%. One acute test value with an LC_{50} of 57.96 had 0% survival in 100% effluent. Chronic toxicity tests results showed NOEC survival ranging between 6% and 100%, NOEC growth rates ranged between 1.5% and 100%, and percent survival in 100% effluent ranging from 0% to 100%.

The CSX facility did exceed its NDPES WET permitted limit of 1 for acute toxicity once (Table 3-19).

3.3.2 Discharge Monitoring Reports (DMR) and Nutrient Monitoring Reports (NMR) for TN and TP

DMR data of Clifton Forge City STP, Covington City STP, and Mead Westvaco Packaging Resource Group are presented for total nitrogen (TN) and total phosphorus (TP) (Table 3-20). In addition, TN and TP data collected between October 2004 and July 2005 recorded in NMR reports are also presented (Table 3-21).

Table 3-20: DMR data presenting TN and TP for Mead Westvaco, Covington City STP, and Clifton Forge City STP

Facility Name	Permit No	Total Nitrogen				Total Phosphorus			
		kg/day		mg/L		kg/day		mg/L	
		Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
Mead Westvaco	VA0003646	-	-	-	2.81	-	-	-	2.16
Covington City STP	VA0025542	78.19	97.51	10.97	13.04	8.84	16.19	1.23	2.01
Clifton Forge City STP	VA0022772	59.23	-	9.46	-	21.2	-	3.39	-

Table 3-21: Monitoring Report Data of Covington City STP for TN and TP

Facility Name	Permit No.	Parameters Reported	# Records	NMR Reported Values			
				Quantity		Conc.	
				Avg	Max	Avg	Max
Covington City STP	VA0025542 (Outfall #1)	Nitrogen, Total as N (KG/MO)	7	-	357.14	-	-
		Nitrogen, Total as N (KG/YR)	7	-	1912.61	-	-
		Phosphorus, Total (as P)	7	12.44	22.31	1.59	2.74
		Phosphorus, Total (as P) (KG/MO)	7	-	50.09	-	-
		Phosphorus, Total (as P) (KG/YR)	7	-	213.94	-	-

3.4 Flow Modification and Dissolved Oxygen Levels

The Jackson River flow is impacted by the releases from the Gathright Dam. This section presents an analysis of the streamflow and dissolved oxygen data in order to evaluate the likelihood of flow regulation affecting the water quality in the Jackson River. A low-flow analysis at three stations on the Jackson River is presented to assess the critical low flow conditions in the Jackson River and identify any release pattern from Gathright Dam. This low-flow analysis is then combined with the continuous monitoring DO data in order to identify any contribution from the flow releases on the DO levels in the Jackson River.

3.4.1 Low-Flow Analysis in the Jackson River

Streamflow data recorded from the period of 1984 to 2005 at the USGS Station 02013100 (City Playground Station) were analyzed in order to determine the average flow regime. This station is representative of the flow conditions in the Jackson River since flow at this station includes flow from the Gathright Dam and the Dunlap Creek in addition to any lateral wet-weather flows. Figure 3-22 presents the monthly average flows at the City Playground Station and depicts the overall flow regime in the Jackson River.

Figure 3-22: 1985-2004 Monthly Average Flows at the City Playground (USGS021013100)

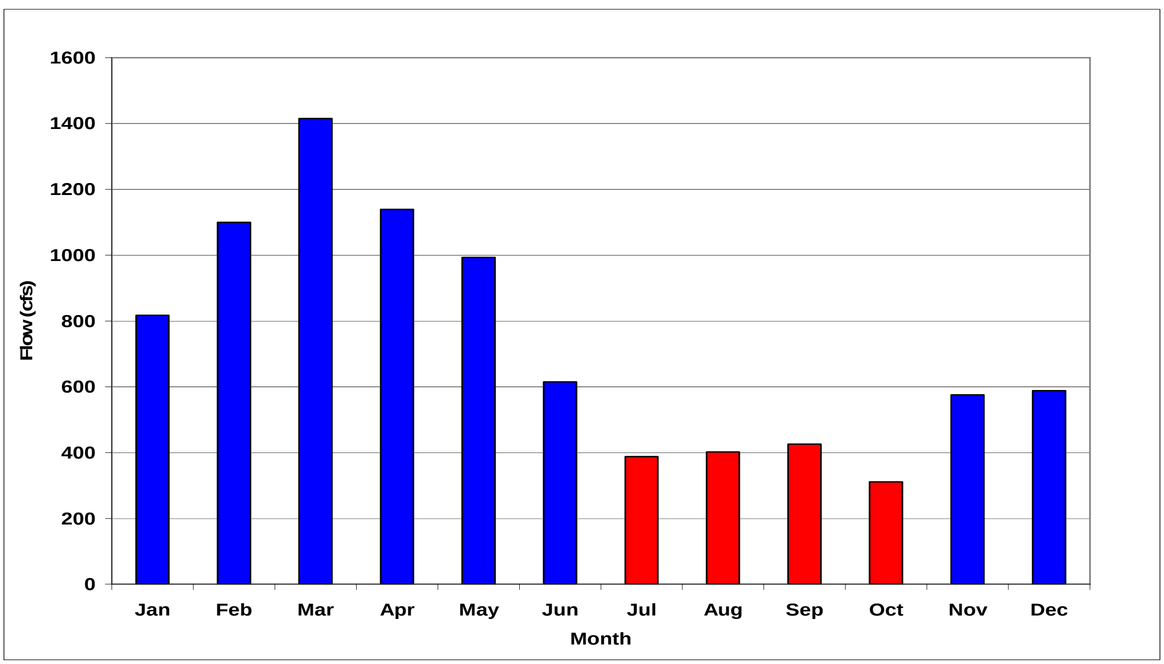


Figure 3-26 shows that the lowest monthly-average flows occur during the months of July, August, September, and October. The lowest monthly-average flow was recorded in October (1985-2004).

Critical periods in water quality often occur during short periods of one to two weeks. Consequently, weekly low-flow analysis was performed on the streamflow data at the City Playground Station. This analysis consists of identifying the lowest weekly-average flow in the Jackson River for each year spanning the period of 1984 to 2005 and during the 4-month period of July, August, September and October. Table 3-21 shows the results of the analysis and indicates that most of the time, the lowest weekly-average flow occurs the month of October.

Table 3-22: Lowest Weekly Average Flow Occurring[1] each Year (1984 -2005)

Year	Week	City Playground USGS 02013100 (cfs)	Gathright Dam USGS 02011800 (cfs)	Dunlap Creek USGS 02013000 (cfs)	% of Stream Flow from Gathright Release[2]
1984	Oct 7 - Oct 13	241	179	36	74
1985	Oct 3 - Oct 10	204	149	19	73
1986	Oct 18 - Oct 24	202	178	21	88
1987	Sept 30 - Oct 6	222	179	29	81
1988	Oct 14 - Oct 20	192	172	17	90
1989	Oct 10 -Oct 16	393	224	87	57
1990	Oct 1 - Oct 7	214	186	16	87
1991	Oct 16 - Oct 22	244	198	19	81
1992	Oct 24 - Oct 30	238	191	33	80
1993	Oct 15 - Oct 21	217	199	22	92
1994	Oct 7 - Oct 13	213	189	22	89
1995	Oct 25- Oct 30	247	199	35	81
1996	Oct 3 - Oct 9	257	181	40	70
1997	Oct 5 - Oct 11	250	192	16	77
1998	Oct 25 - Oct 31	232	199	17	86
1999	Oct 25 - Oct 31	191	156	34	82
2000	Oct 3 - Oct 9	258	191	36	74
2001	Oct 3 - Oct 9	231	191	14	83
2002	Oct 4 - Oct 10	189	149	22	79
2003	Oct 7 - Oct 14	271	187	42	69
2004	Sept 1 – Sept 7	286	191	71	61
2005[3]	Sept 30 - Oct 6	250	212	19	85

[1] during the critical months of July, August, September, and October
[2] percent of flow from the Gathright Dam release at the City Playground station
[3] provisional USGS flow data – subject to revision

The lowest weekly-average flow recorded is in October 2002 (189 cfs, October 4 to October 10). The highest weekly-average flow recorded is in October 1989 (393 cfs, October 10 to October 16). Table 3-21 also shows that during these critical periods the Gathright Dam release consists of approximately 70 to 90 percent of the total flow at the City Playground Station. It should be noted that the Gathright Dam operations manual specifies a minimum flow release of 188 cfs above Dunlap Creek, however, during the week of October 4 though October 10, 2002 the Gathright Dam's release averaged 149 cfs (Table 3-21).

3.4.2 Continuous DO Monitoring

The results of the low-flow analysis were combined with the continuous diurnal dissolved oxygen observations recorded in the fall of 2002, 2004, and 2005. This information is presented in Figure 3-8 through 3-10, and reproduced below in Figures 3-27 through 3-29 with the addition of the stream flows recorded during the same period. Streamflow data presented in Figures 3-27 through 3-29 consist of data from the City Playground, Dunlap Creek, and Gathright Dam.

The key observation of this analysis that the lowest weekly average flow on record (October 4 to October 10, 2002) coincides with the lowest observed diurnal dissolved oxygen concentration of 0.74 mg/L recorded on October 6, 2002 (Figure 3-21). In addition, the lowest critical weekly flow also coincides with the highest diurnal DO fluctuations of over 7 mg/L. It should be noted that these low-DO observations coincide with critical weekly flow with has an average return period of 21 years. In other words, this low diurnal DO, which corresponds to an extreme low-flow condition, is considered as an extreme event. Figure 3-21 also shows that the low-DO observations also coincide with above-normal seasonal ambient temperature.

Other information deducted from Figure 3-21 is that the critical weekly low-flow period of October 4 to October 10, 2002 was preceded by a major wet-weather event. As depicted in Figure 3-27, the flow at the City Playground station increased to 724 cfs on October 27, 2002 following a rainfall event of 1.90 inches recorded on October 26 at the Gathright Dam precipitation station.

The wet weather event suggests that the diurnal low DO might not be solely caused by the critical low flow experienced in the Jackson River. However, the dissolved oxygen critical drop occurred almost a week after the wet-weather event making it unlikely to have contributed or caused directly this low oxygen level in the Jackson River.

On the other hand, the diurnal DO data recorded between October 29 and November 1 2004 do not violate instream dissolved oxygen standards (Figure 3-22). The weekly average flow during this period is 322 cfs at the city playground, well above the 2004 critical weekly flow of 286 cfs recorded during the week of September 1 to September 7 2004 (Table 3-21).

Diurnal dissolved oxygen data collected in the fall of 2005 violate the DO standard. As shown in Figure 3-23, DO levels dropped below the minimum standard during the night of October 4 to October 5 2005. However, the DO violation in the fall of 2005 cannot be solely attributed to flow conditions. The flow at this period was the lowest weekly average flow recorded in 2005 (July, August, September, and October 2005), however, the flow rate of 250 cfs is well above the critical low-flow conditions shown in Table 3-21. It should be noted that the flow for this period was retrieved from the USGS real-time flow web site, and all the data from this site is provisional. The final analysis and conclusion on the diurnal DO data for the fall 2005 will be adjusted when final flow data is available from USGS.

Figure 3-21: Jackson River Dissolved Oxygen and Flow - Fall 2002

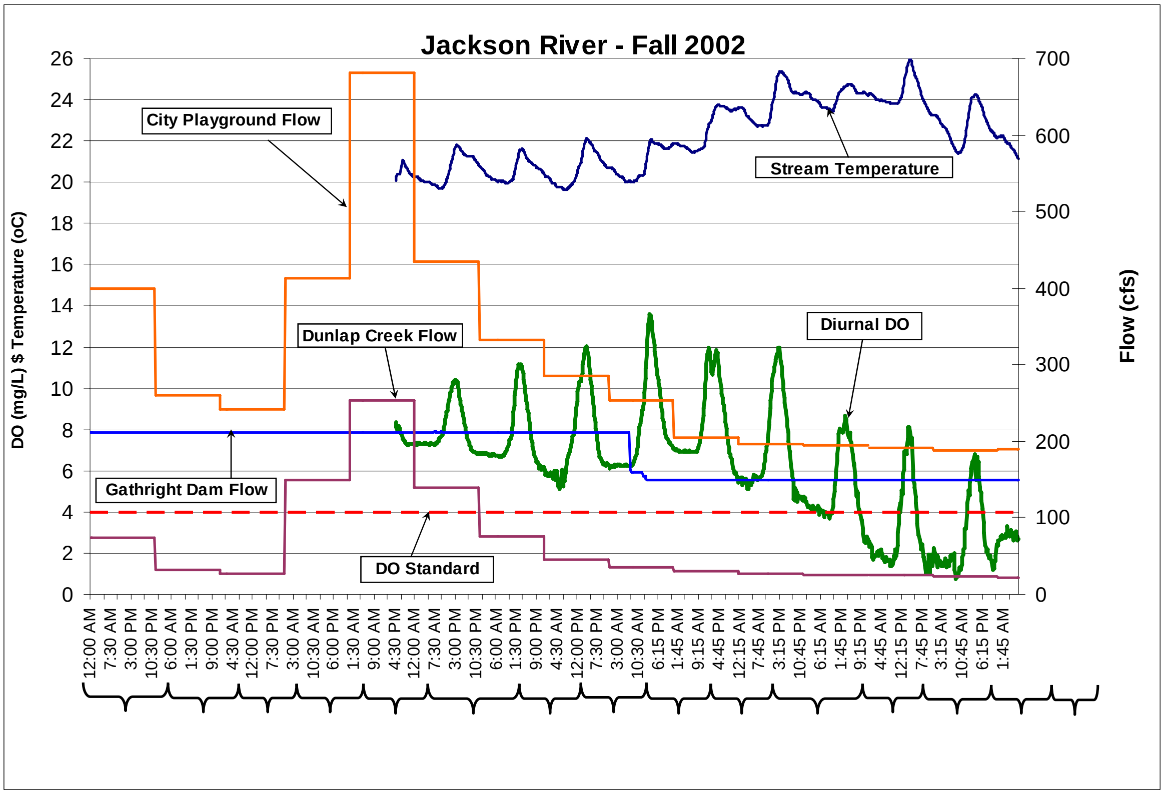


Figure 3-22: Jackson River Dissolved Oxygen and Flow – Fall 2004

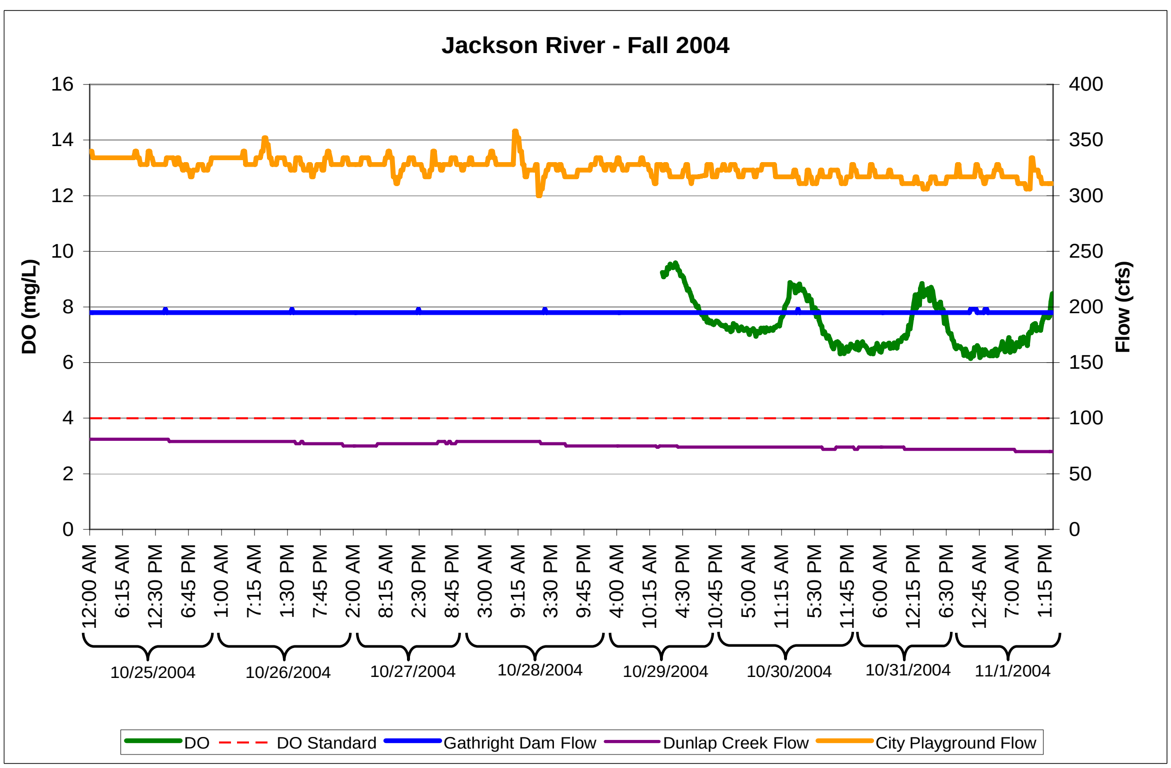
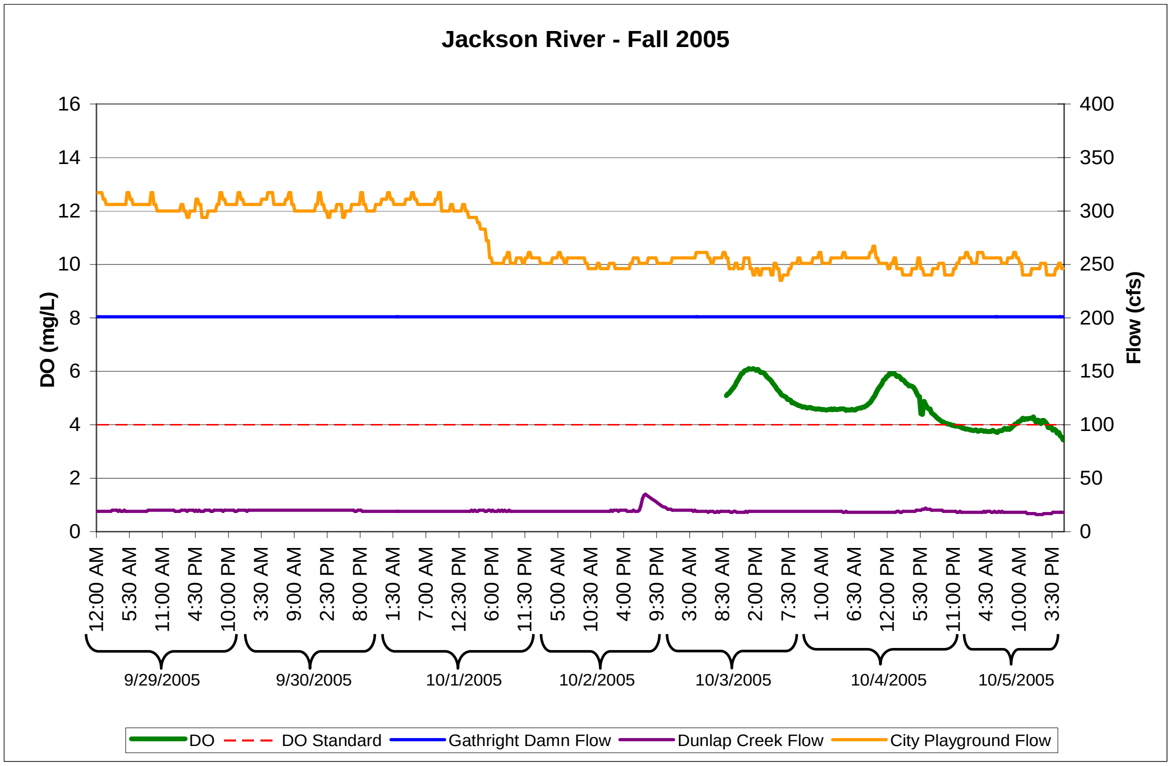


Figure 3-23: Jackson River Dissolved Oxygen and Flow – Fall 2005



4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) affecting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segment of the Jackson River was performed using the available environmental monitoring and watershed characterization data discussed in previous sections. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA 2000).

The identification of the most probable cause of biological impairment in the Jackson River was based on evaluations of candidate stressors that can potentially impact the river. The 2004 Water Quality Assessment 305(b)/303(d) Integrated Report Fact Sheet identified "nutrient and organic enrichment" as possible sources of biological impairment. Therefore, these pollutants were considered in the evaluation of candidate stressors along with other probable stressors such as pH, temperature, dissolved oxygen, sediment, ammonia, flow modification, and toxic compounds. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Furthermore, potential stressors were classified as a *non-stressor*, *possible stressor*, or *most probable stressor*. Table 4.1 summarizes the results of the analysis.

Table 4.1: Summary of Stressor Identification in the Jackson River

Parameter	Location in Document
Non-Stressors	
Temperature and pH	Section 4.1.1
Metals and Organics	Section 4.1.2
Sediments	Section 4.1.3
Wet Weather	Section 4.1.4
Possible Stressors	
TDS-Toxicity	Section 4.2.1
Low Dissolved Oxygen	Section 4.2.2
Flow Modification	Section 4.2.3
Most Probable Stressors	
Nutrients/Periphyton	Section 4.3.1

4.1 Non-Stressors

4.1.1. Temperature and pH

Benthic invertebrates require a suitable range of temperature and pH conditions. Although these ranges may vary by invertebrate phylogeny, high instream temperature values and either very high or very low pH values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms. The Virginia Class IV water quality standards identify the acceptable pH and temperature ranges for the Jackson River. Field measurements indicated adequate temperature and pH values on and upstream of the biologically impaired segment (Figures 3-4 and 3-5). There have been no observed violations of Class IV water quality standards for pH and temperature. Therefore, pH and temperature do not appear to be adversely impacting benthic communities in the Jackson River.

4.1.2. Metals and Organics

Analysis of the available DEQ water quality data indicated no dissolved metals parameters exceeded Virginia's established water quality standards (Table 3-6), and only nickel values exceeded the sediment screening values at River mile 6 and 0.38 which are downstream of the impaired segment (Table 3-7). Observed dissolved metals concentrations in the effluent of the MeadWestvaco facility, the largest discharger on the Jackson River, were also low across all parameters (Table 3-14), indicating that MeadWestvaco is not a significant contributor of metals loading to the river. Metals and organics data collected by DEQ do not suggest the presence of toxicity in the Jackson River. Therefore, metals and organics do not appear to be a primary stressor impacting the benthic macroinvertebrates in the Jackson River.

4.1.3. Sediments

Excessive sediment loading can negatively impact benthic invertebrate communities by silting over invertebrate habitat, choking invertebrates with suspended sediment particles, and bringing invertebrates into contact with other pollutants that enter surface water via adhesion to sediment particles.

Habitat metrics collected during biological monitoring surveys did show a trend of habitat conditions declining as sampling moved from upstream to downstream (Figures 3-1 to 3-3; Appendix A), substrate embeddedness scores and other indicators of sediment loading did not substantially vary from the overall trend. The Jackson River is a point source dominated stream along the length of the impaired segment, and the observed decline in habitat conditions is likely a result of the point sources discharges. Average effluent suspended solids concentrations were generally low for most of the major dischargers (i.e., facilities with design flows greater than 1 MGD) in the watershed (Figure 3-20). Additionally, total suspended solids concentrations collected downstream of the MeadWestvaco plant, the largest discharger present on the river, were consistently low across monitoring stations (Table 3-12). Because the Jackson River watershed is largely forested (Table 2-3), excessive non-point source sediment loading to the river is also unlikely. For the reasons stated above, sediment is considered as a non-stressor in the Jackson River.

4.1.4. Wet-Weather Flow – Non-Point Sources

A wet weather event preceding the low diurnal DO conditions observed in October 2002 suggests that non-point sources loads night have contributed to the low-DO conditions (Figure 3-17). However, the storm preceding the DO incursion below 4 mg/L is an average high-flow event and the low observed DO occurred almost one week after this wet weather. Consequently, this wet-weather event is unlikely to have directly caused or contributed to the DO drop. Therefore, non-point sources loading under wet-weather flow is considered as a non-stressor in the Jackson River.

4.2 Possible Stressors

4-2.1 TDS and Toxicity

The toxicity data analysis presented in Sections 3.1.2 (WET toxicity) and 3.2.3 (Instream Toxicity Testing), indicates that there is some degree of toxicity in the Jackson River. The overall conclusion is that the toxicity results are probably biologically significant. Toxicity in the Jackson River is not attributed to the levels of ammonia, metals, and organics since they were low across all monitoring stations. However, toxicity is often caused by relatively high Total Dissolved Solids (TDS) concentrations. Aquatic organisms are highly sensitive to elevated TDS concentrations, which can reduce water quality and significantly impact fish and wildlife (Chapman et al. 2000).

In fact, conductivity data collected at different stations in the Jackson River exhibit extremely high concentrations as compared to a reference station (Figure 3-9). Conductivity is an appropriate surrogate for TDS since the degree of conductivity is directly proportional to the concentration of total dissolved solids in water. For the reasons stated above, TDS and toxicity are considered as possible stressors affecting the benthic macroinvertebrate community in the Jackson River.

4.2.2 Low Dissolved Oxygen

Adequate dissolved oxygen levels are necessary for invertebrates and other aquatic organisms to survive in the benthic sediments of rivers or streams. Decreases in instream oxygen levels can result in oxygen depletion or anoxic sediments, which adversely impact the river's benthic community. As discussed in the preceding section, diurnal dissolved oxygen studies showed large diurnal fluctuations in instream oxygen concentrations (Figures 3-16) and violated dissolved oxygen standards for Class IV waters (Figure 3-16 and Figure 3-18).

However, the severe violations observed in the fall of 2002 coincide with an extreme low-flow event and are episodic in nature. In addition the low-flow events associated with the low-DO were combined with above-normal seasonal ambient temperature

(Figure 3-21). In other words, the low dissolved oxygen might contribute occasionally to the benthic impairment; however, it cannot be classified as the primary stressor causing the benthic impairment in the Jackson River. Consequently, dissolved oxygen is classified as a possible stressor affecting the benthic macroinvertebrate community in the Jackson River.

4.2.3 Flow Modification

Section 3-4 addressed any potential contribution of the flow release at Gathright Dam on the overall dissolved levels during critical low flow events. One indication is that the worst DO levels recorded in the Jackson River (October 2002) coincide with an extreme weekly low-flow event. However, this observation is not confirmed with the diurnal DO measurements taken in October 2005. In fact, dissolved oxygen levels in 2005 fall below the minimum DO standard of 4 mg/L; however, they do not coincide with an extreme low-flow event. In addition the biological data collected along the Jackson River strongly suggest that the flow modification is not the direct cause of the benthic impairment. In fact, key habitat scores such as Substrate Embeddedness, Riparian Vegetation as well as the Total Habitat score indicate a healthy benthic community upstream of the major dischargers in the Jackson River (Section 3.1.3). Therefore, the flow modification is classified as a possible stressor affecting the benthic macroinvertebrate community in the Jackson River.

4.3 Most Probable Stressors

4.3.1 Nutrients

High nitrogen and phosphorus concentrations can stimulate algal growth, which may result in eutrophic conditions, high organic loading, and decreased dissolved oxygen. High nutrient concentrations were observed in the Jackson River, and do appear to be resulting in significant periphyton growth which may impact the benthic macroinvertebrates present in the river. DEQ ambient instream monitoring indicated that total phosphorus concentrations increase significantly in the Jackson River at station 2JKS023.61, below the MeadWestvaco facility and at the upstream end of the biologically impaired segment (Figure 3-12). Monitoring data collected by MeadWestvaco confirmed this trend, and indicate that instream phosphorus concentrations were elevated below the MeadWestvaco plant as compared to stations upstream of the facility (Table 3-13). Instream nitrogen concentrations also increase significantly as the Jackson River flows downstream (Figure 3-9; Table 3-13).

Because the Jackson River is effluent-dominated under low flow conditions (when excessive periphyton growth and algal blooms are prone to occur), point sources appear to be the predominant source of the excessive nutrient loading present in the river. Only two major dischargers (i.e., facilities with design flows greater than 1 MGD) monitored their effluent for total nitrogen and total phosphorus. Phosphorus concentrations in the effluent of both of these facilities, MeadWestvaco and the Clifton Forge City STP, were generally elevated (Figure 3-25). Effluent nitrogen concentrations were also fairly high at the Clifton Forge STP, and on some occasions at the MeadWestvaco plant (Figure 3-24). Additionally, instream monitoring conducted immediately downstream of other facilities (e.g., the Covington City STP) also indicates that some facilities which do not currently monitor their effluent for nutrients may nonetheless be contributing large nutrient loads to the Jackson River, as evidenced by the spike in nitrogen and phosphorus concentrations observed at these monitoring stations (Figures 3-9, 3-11; Table 3-13).

Periphyton data collected in the Jackson River correspond to the patterns of nutrient loading observed. Periphyton are attached algae that grow on the bottom of stream beds, and represent the dominant type of algal biomass in lotic ecosystems. In addition to contributing to high organic loading, excessive periphyton can also impair benthic macroinvertebrate assemblages by covering the interstitial spaces between rocks and cobble that comprise much of the habitat for many types of invertebrates. Observed periphyton chlorophyll A values increased at the Mill Dam and Mill Bridge stations, located in the immediate vicinity of the MeadWestvaco facility, and showed another spike near the Playground, Skate Park, and Industrial Park monitoring stations, located downstream of several additional point sources (Table 3-15).

Further evidence of excessive nutrient loading was indicated by diurnal dissolved oxygen studies, which demonstrated that large diurnal swings in dissolved oxygen occur in the Jackson River under low flow, effluent-dominated conditions (Figures 3-14 to 3-16). These large diurnal oxygen swings are often indicative of eutrophic conditions, and result from increased algal biomass contributing to organic enrichment of the river. During the daylight hours, the algae photosynthesize and increase the dissolved oxygen present in the river. However, in the evening the algae are not able to photosynthesize, but microbial respiration continues to occur as decomposition of the excessive organic matter persists. This results in large diurnal oxygen swings, such as those observed in the Jackson River, in which dissolved oxygen concentrations peak in the daylight hours, and fall to very low levels in the evening. The fact that this pattern was observed repeatedly in the Jackson River strongly suggests that nutrient loading leading to excessive periphyton growth is adversely impacting the biological communities in the river.

Benthic macroinvertebrate assemblages are generally sensitive to organically enriched conditions. Excess nutrients entering the river system over-stimulate algal growth which can alter macroinvertebrates communities by providing an increase in food supply for opportunistic invertebrates that use algae as a food source. These opportunistic invertebrates are often generalists and can easily outcompete more sensitive species and dominate a community (EPA, 2000). At the same time, the benthic macroinvertebrate community is also affected by a change in instream habitat since the abundance of periphyton will cover the majority of instream habitat areas. These affects on the species composition alters the natural balance in the benthic community and creates a shift toward pollution tolerant organisms that feed on algae (scrapers) and suspended detritus (collector-filterers) (Voshell, 2002). Overall, an increase in nutrients will lower the macroinvertebrate species diversity and reduce the variety of food available for fish and other vertebrates present within the ecosystem.

For the reasons stated above, excessive nutrient loading leading to eutrophic conditions is considered to be a most probable stressor impacting benthic invertebrates in the Jackson River. Stoichiometric nutrient ratios indicate that the Jackson River is primarily a phosphorus-limited stream (Figures 3-9, 3-11; Table 3-13). Therefore, nutrients (primarily phosphorus) are considered to be a most probable stressor affecting the benthic macroinvertebrate community in the Jackson River.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicate that temperature, pH, and sediments in the biologically impaired segment of the river are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. Concentrations of metals and organics were generally low or below analytical detection limits and are also classified as non-stressors. In addition, non-point sources loading under wet-weather flow is also considered as a non-stressor in the Jackson River since the existing data indicate that the wet-weather event in Figure (3-21) occurred one week prior to the low observed DO and therefore is unlikely to have directly caused the decrease in dissolved oxygen levels.

The data analysis also shows that high TDS in the stream and TDS related toxicity, low-dissolved oxygen episodically associated with low-flow conditions also can contribute to the benthic impairment in the Jackson River. In addition the flow modification/regulation caused by the Gathright Dam is also classified as possible stressor to the benthic community in the Jackson River. Consequently, low-dissolved oxygen, flow modification as well as high TDS concentrations and toxicity are classified as possible stressors.

Excessive periphyton growth caused by an excess of nutrient (in particular phosphorus) has been identified as the most probable stressors impacting benthic invertebrates in the biologically impaired segment of the Jackson River.

Elevated nutrient concentrations were observed downstream of major point sources discharging to the river. Excessive periphyton growth and large diurnal dissolved oxygen swings also indicate the presence of eutrophic conditions in the Jackson River. Because stoichiometric nutrient ratios indicate that the Jackson River is primarily a phosphorus-limited stream, phosphorus is considered a most probable stressor affecting the benthic macroinvertebrate community.

In summary, the data analysis shows that the common “end-point stressor” is the excessive periphyton growth and accumulation in the Jackson River causing the benthic impairment. This excessive periphyton growth is mainly caused by the excessive nutrients in the river.

Consequently, the periphyton issue in the Jackson River would be addressed a reduction in nutrient loadings.

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APPENDIX A

Habitat Parameters Assessed and Scored at Biological Monitoring Stations

Figure A-1: Substrate Embeddedness Scores for Jackson River Monitoring Stations

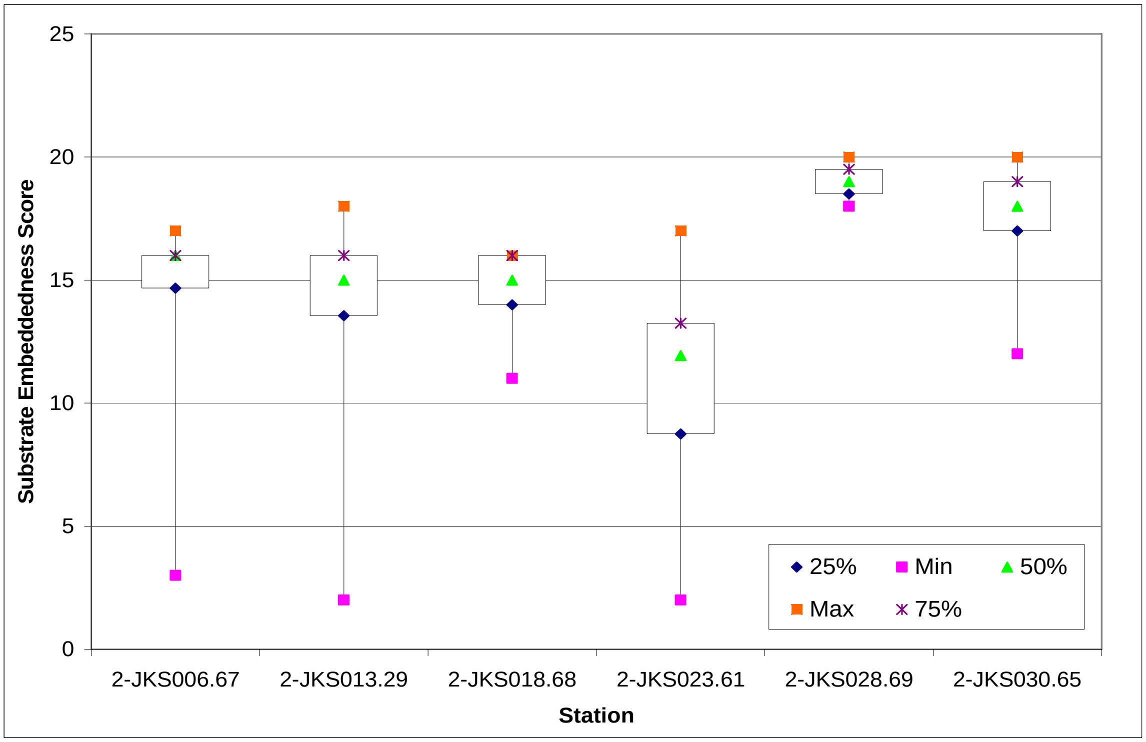


Figure A-2: Channel Alteration Scores for Jackson River Monitoring Stations

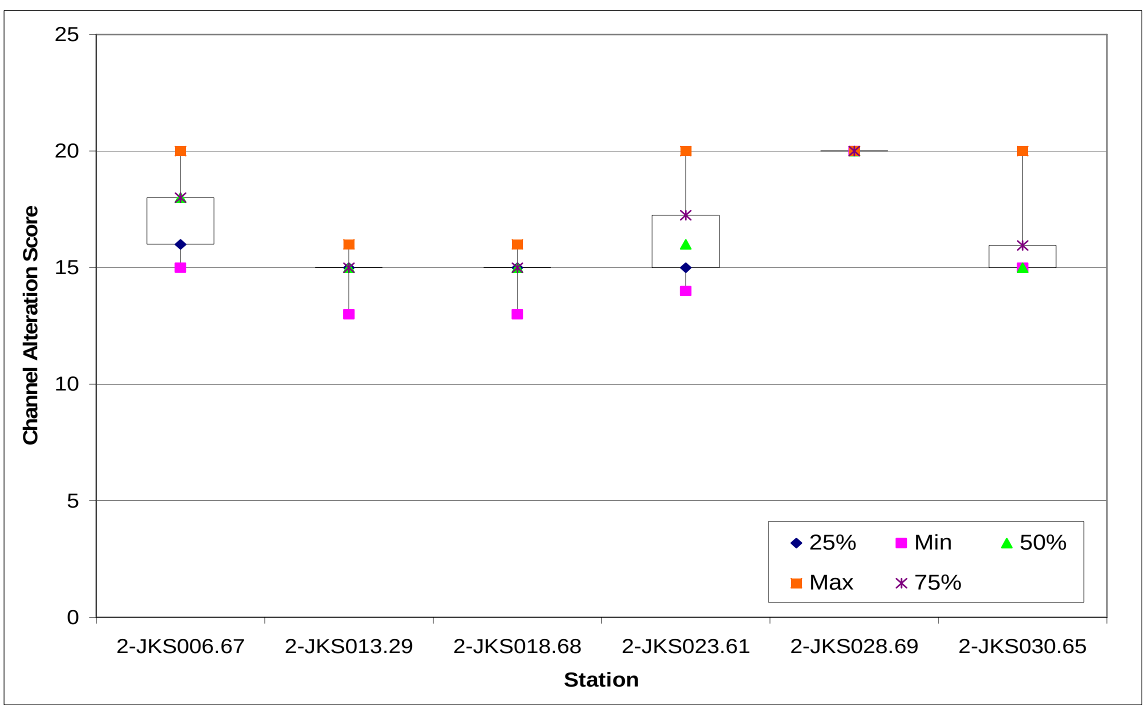


Figure A-3: Bank Stability Scores for Jackson River Monitoring Stations

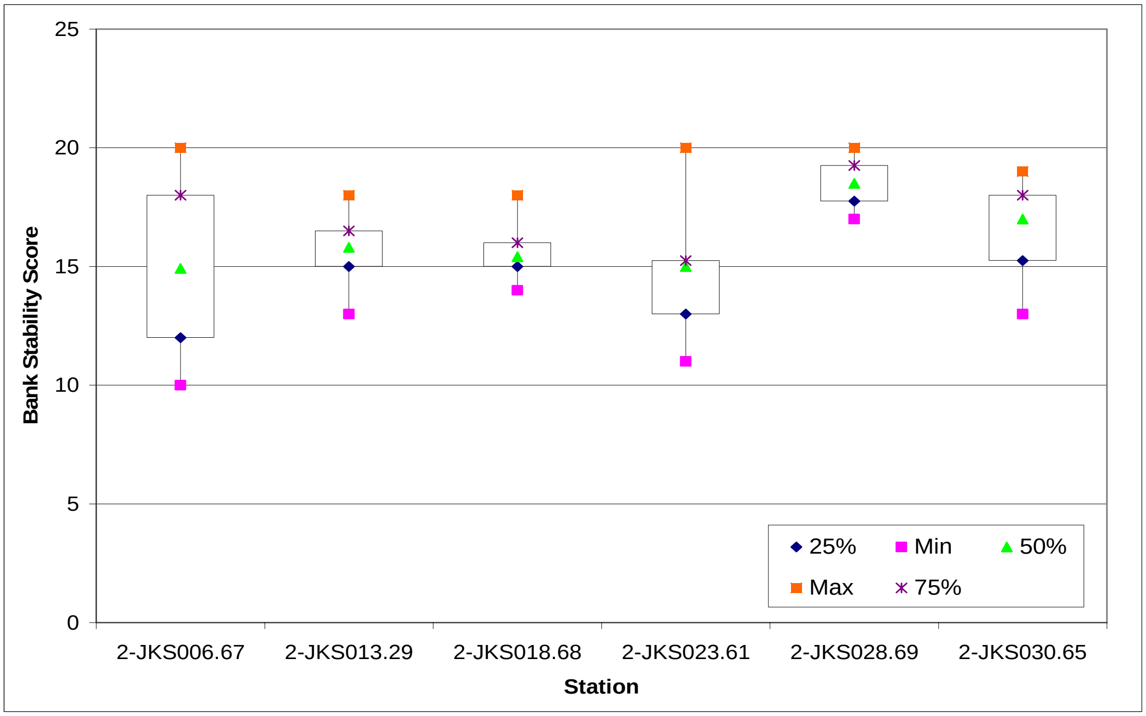


Figure A-4: Bank Vegetation Scores for Jackson River Monitoring Stations

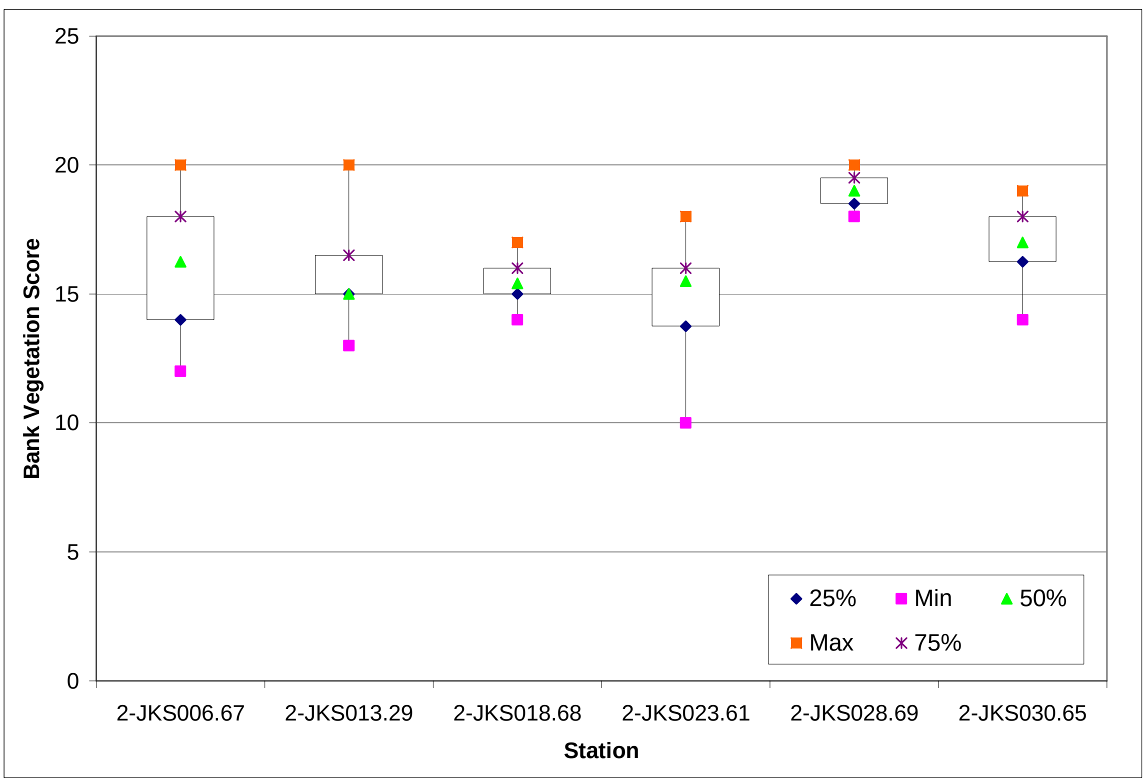


Figure A-5: Riffle Frequency Score for Jackson River Monitoring Stations

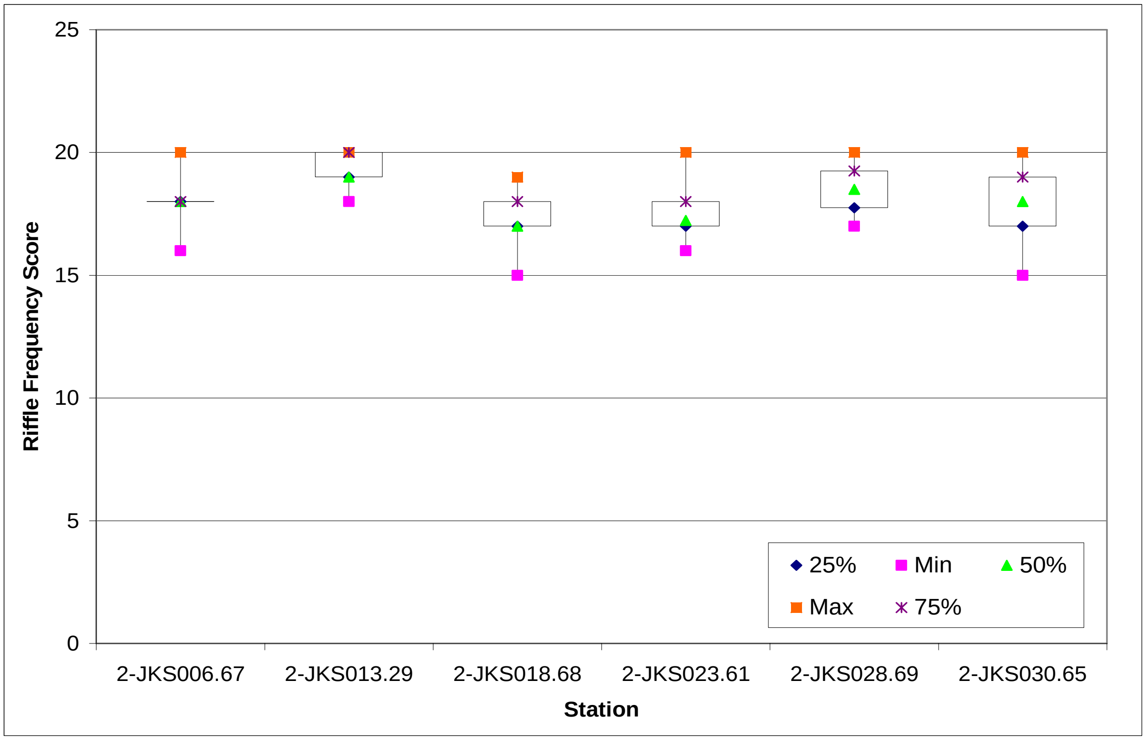


Figure A-6: Channel Flow Scores for Jackson River Monitoring Stations

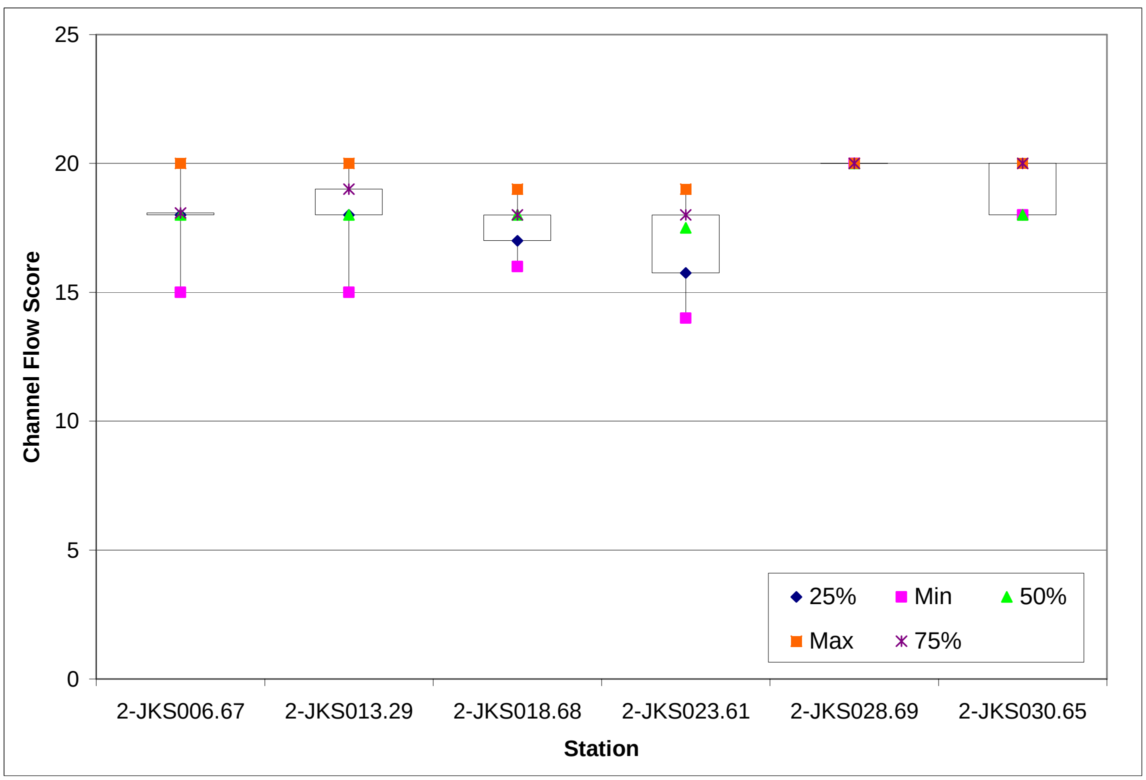


Figure A-7: Riparian Vegetative Zone Scores for Jackson River Monitoring Stations

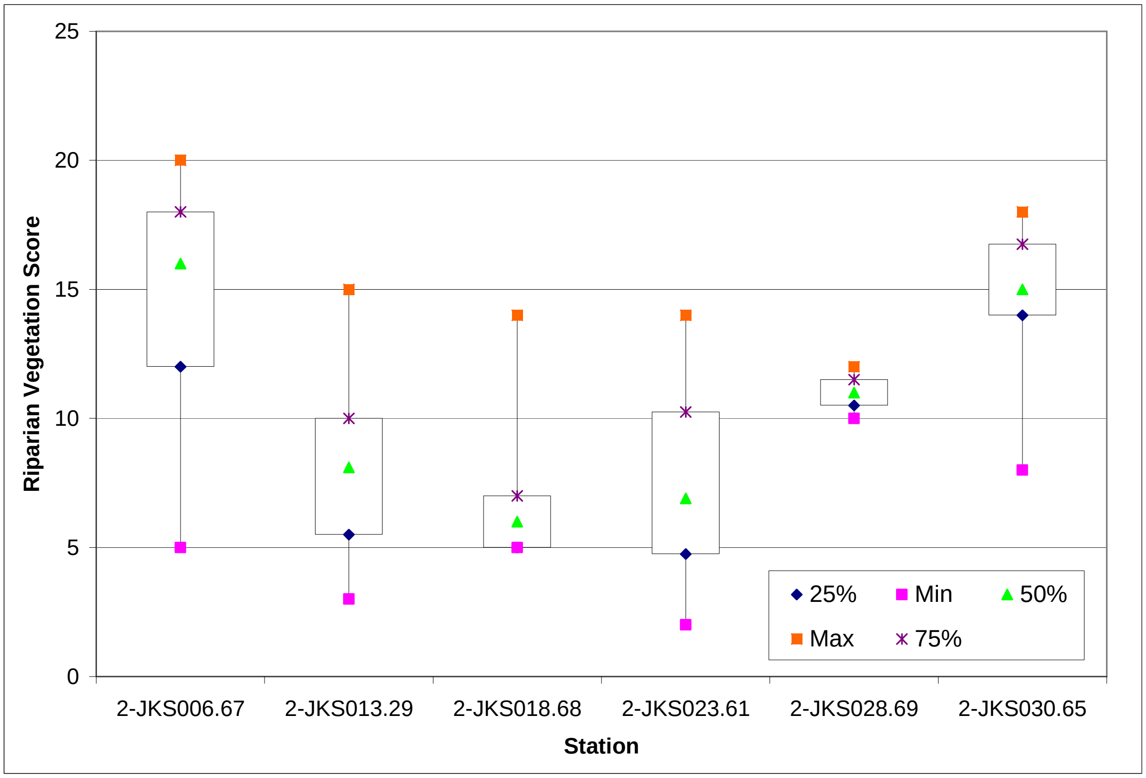


Figure A-8: Sedimentation Scores for Jackson River Monitoring Stations

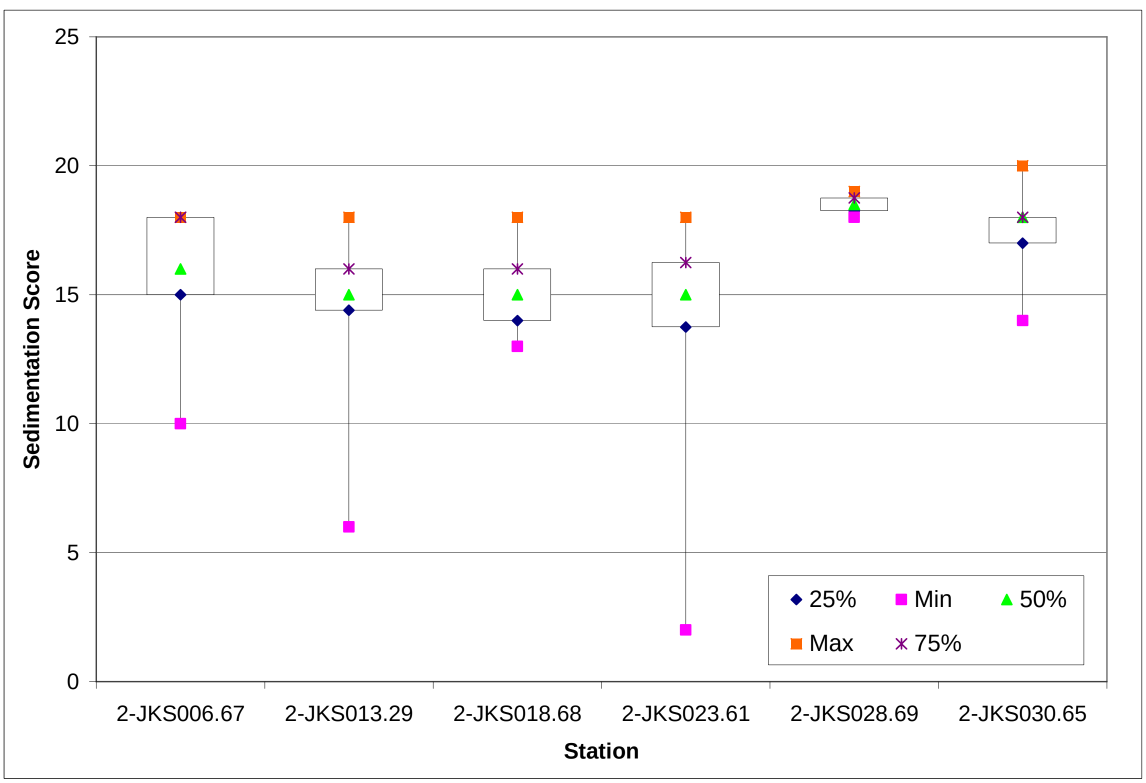


Figure A-9: Channel Velocity Scores for Jackson River Monitoring Stations

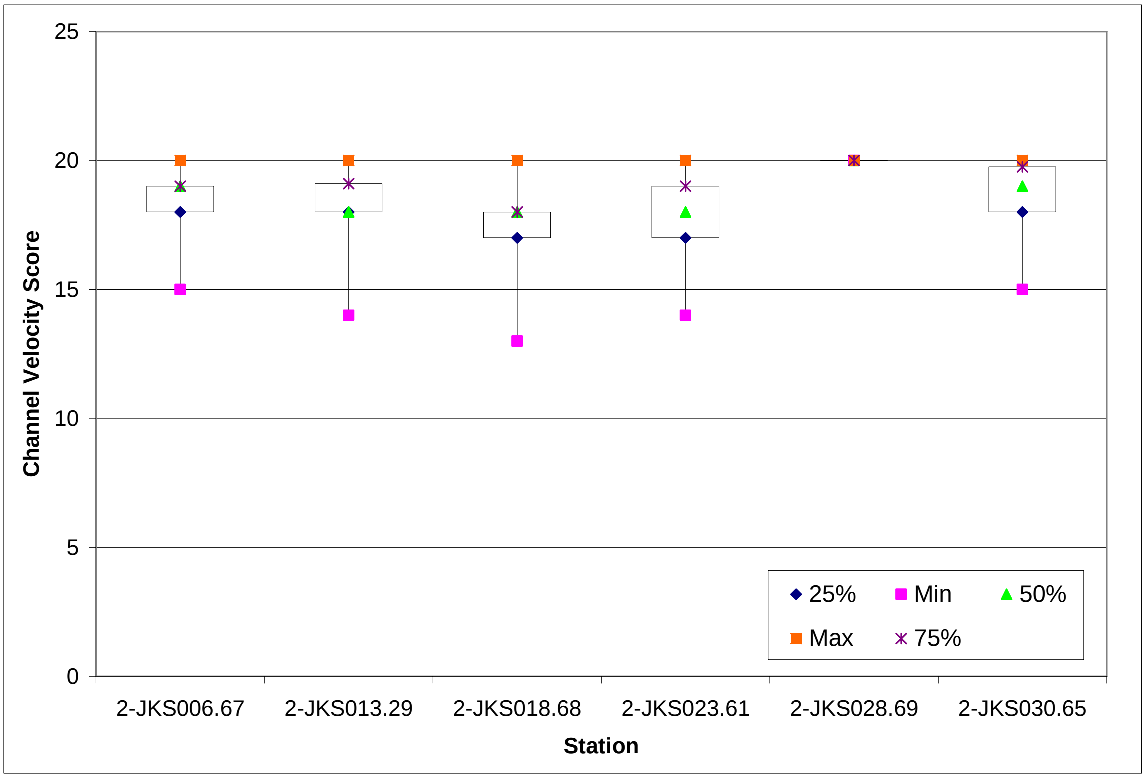
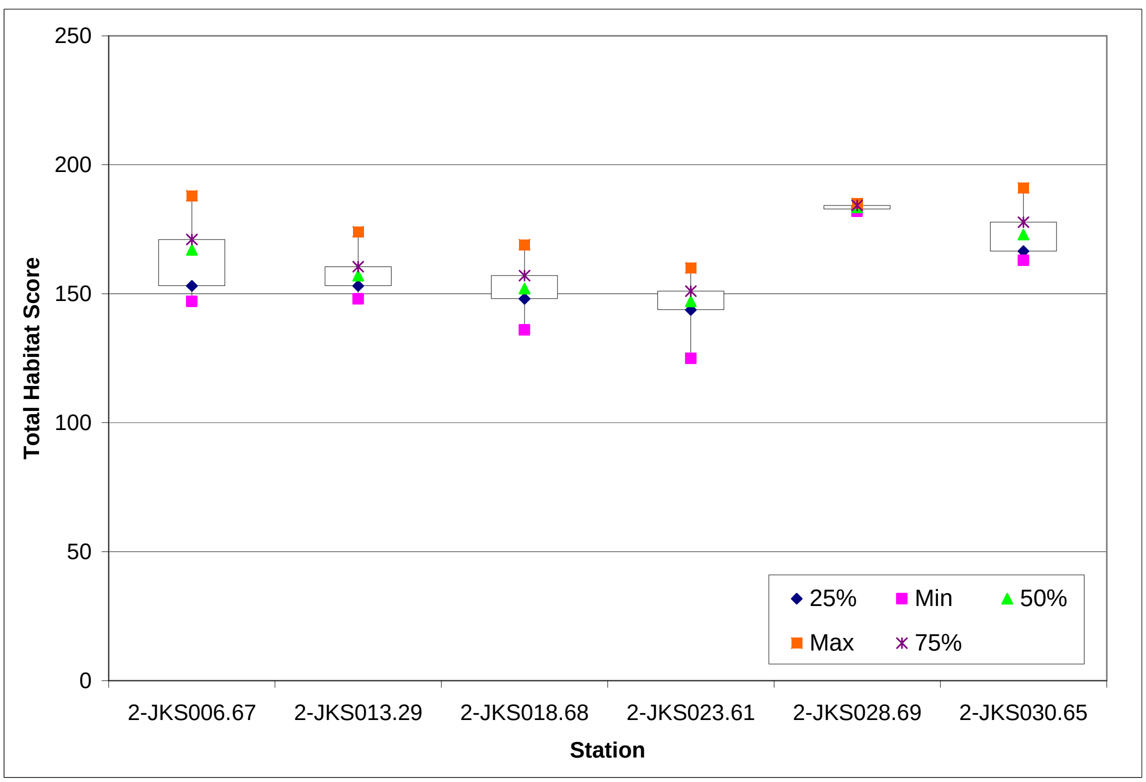


Figure A-10: Total Habitat Scores for Jackson River Monitoring Stations



APPENDIX B

Permitted Discharge Limits
for Facilities Holding Individual Permit

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
Alleghany Co - Low Moor Sewage Treatment Plant	VA0027979	Minor	Municipal	0.5	1	BOD5	22.7	34.1	12	18
						CL2, inst res max tech	********	********	*********	4
						CL2, inst tech min limit	********	********	*********	*********
						CL2, total	********	********	0.22	0.27
						CL2, total contact	********	********	*********	*********
						DO	********	********	*********	*********
						Flow	0.5	NL	*********	*********
						PH	********	********	*********	9
						TSS	56.7	85.4	30	45
Alleghany Co - Lower Jackson River WWTP	VA0090671	Major	Municipal	2	1	BOD5	227.1	340.6	30	45
						CL2, inst res max tech	*********	*********	0.163	0.197
						CL2, inst tech min limit	*********	*********	*********	*********
						CL2, total contact	*********	*********	*********	*********
						Flow	2	NL	*********	*********
						PH	*********	*********	*********	9
						TSS	227.1	340.6	30	45
Applied Extrusion Technologies - Covington	VA0003450	Minor	Industrial	1	1	BOD5	94	184	NL	NL
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9
						Water temperature	*********	*********	*********	31
						TSS	NL	NL	30	60
Applied Extrusion Technologies - Covington	VA0003450	Minor	Industrial	1	2	CL2, total	*********	*********	NL	NL
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						TSS	NL	NL	NL	NL
Applied Extrusion Technologies - Covington	VA0003450	Minor	Industrial	1	102	BOD5	NL	12.3	NL	NL
						Flow	NL	NL	*********	*********
						Oil & Grease	NL	13.72	NL	NL
						pH	*********	*********	*********	9
						TSS	NL	8.98	NL	NL
Applied Extrusion Technologies - Covington	VA0003450	Minor	Industrial	1	103	BOD5	1.9	5.08	NL	NL
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9
						TSS	*********	*********	*********	9
Boys Home Inc - Sewage Treatment Plant	VA0088544	Minor	Municipal	0.024	1	BOD5	2.5	3.8	30	45
						CL2, Inst Res Max	*********	*********	2	2.4
						CL2, Inst Tech Min Limit	*********	*********	*********	*********
						CL2, total contact	*********	*********	*********	*********
						Flow	0.024	NL		
						Oil and Grease	*********	*********	NL	NL
						pH	*********	*********	*********	9
						TSS	2.5	3.8	30	45
Clifton Forge City - Sewage Treatment Plant	VA0022772	Major	Municipal	2	1	BOD5	227	340	30	45
						CL2, Inst Tech Min Limit	*********	*********	*********	*********
						CL2, Total	********	********	106	128
						CL2, Total Contact	*********	*********	*********	*********
						Flow	2	NL	*********	*********
						Nitrite +Nitrate -N,Total	NL	*********	NL	*********
						Nitrate, Total as N	NL	*********	NL	*********
						Nitrogen, Total as N (KG/MO)	********	NL	*********	*********

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						Nitrogen, Total as N (KG/YR)	********	NL	*********	*********
						Orthophosphate (as P)	NL	*********	NL	*********
						pH	*********	*********	*********	9
						Phosphate, total (as P)	NL	********	NL	*********
						Phosphate, total (as P) (KG/MO)	********	NL	*********	*********
						Phosphorus, total (as P) (KG/YR)	********	NL	*********	*********
						TKN (N-KJEL)	NL	*********	NL	*********
						TSS	227	340	30	45
						TUa - Acute 48 HR Stat Pimephales Promelas	********	********	*********	NL
						TUc – Chronic 7 Day Statre Primephales Promelas	********	********	*********	NL
Clifton Forge Water Treatment Plant	VA0006076	Minor	Industrial	-	1	CL2, inst res max	*********	*********	0.016	0.016
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9
						TSS	*********	*********	30	60
Covington City - Sewage Treatment Plant	VA0025542	Major	Municipal	3	1	BOD5	340	510	30	45
						Fecal Coliform	*********	*********	200	*********
						Flow	3	NL	*********	*********
						Nitrogen, Total AS N	NL	NL	NL	NL
						pH	*********	*********	*********	9
						Total Phosphorous	NL	NL	NL	NL
						TSS	340	510	30	45
CSX Transportation Inc - Clifton Forge	VA0003344	Minor	Industrial	0.025	1	Total Organic Carbon	*********	*********	*********	110
						Flow	NL	NL	*********	*********
						Total Nitrogen	*********	*********	*********	NL
						Total Recoverable Petroleum Hydrocarbons	*********	*********	10	15
						pH	*********	*********	*********	9
						Total Phosphorous	*********	*********	*********	NL
						Final Acute Toxicity	*********	*********	*********	1

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						TSS	*********	*********	30	60
DGIF Paint Bank Fish Cultural Station	VA0091324	Minor	Industrial	2.9	1, 2, 3, 4, 5, 6, 7, 8, 9	Ammonia as N	********	********	*********	NL
						Flow	NL	NL	*********	*********
						Settable Solids	********	********	0.1	0.5
						TSS	********	********	10	15
Douthat Road Mobile Home Park STP	VA0089001	Minor	Municipal	0.011	1	BOD5	1.2	1.8	30	45
						CL2 Inst, Res Max	*********	*********	0.08	0.1
						CL2, Inst Teach Limit	*********	*********	*********	*********
						CL2, Total Contact	*********	*********	*********	*********
						Flow	0.011	NL	*********	*********
						pH	*********	*********	*********	9
						TSS	1.2	1.8	30	45
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	32.89	3	Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9
						BOD5	4195	8390	NL	NL
						TSS	17000	33200	NL	NL
						COD	********	********	*********	NL
						Total Phosphorous	********	********	*********	NL
						Total Nitrogen	********	********	NL	NL
						Water Temperatrue (Deg. C)	********	********	*********	43
						Color, PCU	*********	*********	800	NL
						2,3,7,8-TCDD	*********	0.00165	*********	14
						AOX (Adsorbable Organic Halides)	2370	3618	NL	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	4	BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Total Recoverable Iron	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						TSS	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	5	BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Nitrite and Nirtrate, N Total	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
						TSS	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	5	BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Total Recoverable Iron	********	********	*********	NL
						Total Phosphorous	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
						TSS	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	7	BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Total Recoverable Iron	********	********	*********	NL
						Total Phosphorous	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
						TSS	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	8	BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Total Recoverable Iron	********	********	*********	NL
						Total Phosphorous	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
						TSS	********	********	*********	NL

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	9	BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Total Recoverable Iron	********	********	*********	NL
						Total Phosphorous	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
						TSS	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	10	AMMONIA, AS N	********	********	*********	NL
						BOD5	********	*********	*********	NL
						COD	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						Total Recoverable Iron	********	********	*********	NL
						Nitrite and Nitrate, Total	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
						TSS	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	12	BOD5	********	*********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						TKN (N-KJEL)	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	13	BOD5	********	*********	*********	NL
						Color, PCU	********	********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						PH	********	********	*********	NL
						Total Phosphorous	********	********	*********	NL
						TKN (N-KJEL)	********	********	*********	NL
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	15	BOD5	********	*********	*********	NL
						Flow, Precipitation Event	********	NL	*********	*********
						TSS	********	********	*********	NL
MeadWestvaco	VA00036	Major	Industrial	-	301	2,3,4,6-TETRACHLOROPHENOL	********	********	NL	2.5

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
Packaging Resource Group	46					2,3,7,8-TCDD	********	********	NL	10
						2,3,7,8-TETRACHLORODIBENZOFURAN (PPQ)	********	********	NL	31.9
						2,4,5-TRICHLOROPHENOL	********	********	NL	2.5
						2,4,6-TRICHLOROPHENOL	********	********	NL	2.5
						3,4,5-TRICHLOROCATECHOL	********	********	NL	5
						3,4,5-TRICHLOROGUAIACOL	********	********	NL	2.5
						3,4,6-TRICHLOROCATECHOL	********	********	NL	5
						3,4,6-TRICHLOROGUAIACOL	********	********	NL	2.5
						4,5,6-TRICHLOROGUAIACOL	********	********	NL	2.5
						CHLOROFORM (AS CHCL3)	4956	8285	NL	NL
						PENTACHLOROPHENOL	********	********	NL	5
						TETRACHLOROCATECHOL	********	********	NL	5
						TETRACHLOROGUAIACOL	********	********	NL	5
						TRICHLOROSYRINGOL	********	********	NL	2.5
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	302	2,3,4,6-TETRACHLOROPHENOL	********	********	NL	2.5
						2,3,7,8-TCDD	********	********	NL	10
						2,3,7,8-TETRACHLORODIBENZOFURAN (PPQ)	********	********	NL	31.9
						2,4,5-TRICHLOROPHENOL	********	********	NL	2.5
						2,4,6-TRICHLOROPHENOL	********	********	NL	2.5
						3,4,5-TRICHLOROCATECHOL	********	********	NL	5
						3,4,5-TRICHLOROGUAIACOL	********	********	NL	2.5
						3,4,6-TRICHLOROCATECHOL	********	********	NL	5
						3,4,6-TRICHLOROGUAIACOL	********	********	NL	2.5
						4,5,6-TRICHLOROGUAIACOL	********	********	NL	2.5
						CHLOROFORM (AS CHCL3)	5839	9760	NL	NL
						PENTACHLOROPHENOL	********	********	NL	5
						TETRACHLOROCATECHOL	********	********	NL	5

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						TETRACHLOROGUAIACOL	********	********	NL	5
						TRICHLOROSYRINGOL	********	********	NL	2.5
MeadWestvaco Packaging Resource Group	VA0003646	Major	Industrial	-	303	2,3,4,6-TETRACHLOROPHENOL	********	********	NL	2.5
						2,3,7,8-TCDD	********	********	NL	10
						2,3,7,8-TETRACHLORODIBENZOFURAN (PPQ)	********	********	NL	31.9
						2,4,5-TRICHLOROPHENOL	********	********	NL	2.5
						2,4,6-TRICHLOROPHENOL	********	********	NL	2.5
						3,4,5-TRICHLOROCATECHOL	********	********	NL	5
						3,4,5-TRICHLOROGUAIACOL	********	********	NL	2.5
						3,4,6-TRICHLOROCATECHOL	********	********	NL	5
						3,4,6-TRICHLOROGUAIACOL	********	********	NL	2.5
						4,5,6-TRICHLOROGUAIACOL	********	********	NL	2.5
						CHLOROFORM (AS CHCL3)	4956	8285	NL	NL
						PENTACHLOROPHENOL	********	********	NL	5
						TETRACHLOROCATECHOL	********	********	NL	5
						TETRACHLOROGUAIACOL	********	********	NL	5
						TRICHLOROSYRINGOL	********	********	NL	2.5
Morris Hill Sewage Treatment Plant	VA0032115	Minor	Municipal	0.015	1	BOD5	1.7	2.5	30	45
						CL2, Inst Res Max	*********	*********	2	2.4
						CL2, Inst Tech Limit	*********	*********	*********	*********
						CL2, Total Contact	*********	*********	*********	*********
						DO	*********	*********	*********	*********
						Flow	0.015	NL	*********	*********
						pH	*********	*********	*********	9
						TSS	1.7	2.5	30	45
						BOD5	*********	*********	NL	NL
						Flow	NL	NL	*********	*********
						Water Temperature (DEG. C)	*********	*********	*********	31

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	0.208	1	BOD5	*********	*********	NL	NL
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9
						Water Temperature (DEG. C)	*********	*********	*********	31
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	-	2	BOD5	*********	*********	NL	NL
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9
						Water Temperature (DEG. C)	*********	*********	*********	31
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	-	3	Flow, Precipitation Event	********	NL	*********	*********
						pH	********	********	*********	NL
						Zinc, Total Recoverable	********	********	*********	NL
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	-	5	Flow, Precipitation Event	********	NL	*********	*********
						pH	********	********	*********	NL
						Zinc, Total Recoverable	********	********	*********	NL
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	-	901	Flow, Precipitation Event	********	NL	*********	*********
						pH	********	********	*********	9
						Water Temperature (DEG. C)	********	********	*********	31
						Zinc, Total Recoverable	********	********	*********	NL
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	-	902	Flow, Precipitation Event	********	NL	*********	*********
						pH	********	********	*********	9
						Water Temperature (DEG. C)	********	********	*********	31
						Zinc, Total Recoverable	********	********	*********	NL
Parker Hannifin Powertrain Division	VA0002984	Minor	Industrial	-	999	BOD5	6	9	*********	*********
Sponaugle Subdivision	VA0088552	Minor	Municipal	0.016	1	BOD5	1.82	2.72	30	45
						CL2, Inst Res Max	********	********	2	2.4
						CL2, Inst Teach Limit	********	********	*********	*********

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						CL2, Total Contact	********	********	*********	*********
						Flow	0.016	NL	*********	*********
						pH	*********	*********	*********	9
						TSS	1.82	2.72	30	45
Tanglewood Manor Home for Adults Inc	VA0090646	Minor	Municipal	0.018	1	Ammonia, as N Jan-May	********	********	2.1	2.1
						Ammonia, as N Jun-Dec	********	********	1.6	1.6
						CBOD5, Jan-May	1.6	2.4	24	36
						CBOD5, Jun-Dec	1	1.5	15	22.5
						CL2, Inst Res Max	*********	*********	0.007	0.009
						CL2, Inst Tech Min Limit	*********	*********	*********	*********
						CL2, Total Contact	*********	*********	*********	*********
						Fecal Coliform			20	
						DO, Jan- May	********	********	*********	*********
						DO, Jun-Dec	********	********	*********	*********
						Flow	0.018	NL	*********	*********
						pH	*********	*********	*********	8.1
						TKN, Jan- May	********	********	9	13.5
						TKN, Jun-Dec	*********	********	5.1	7.6
						TSS	2	3	30	45
VDOT I64 Rest Area - Alleghany Co	VA0075574	Minor	Municipal	0.015	1	Ammonia, as N Jan-May	*********	*********	4	4
						Ammonia, as N Jun-Dec	*********	*********	3.1	3.1
						BOD5, Jan-May	1.7	2.5	30	45
						CBOD5, Jun-Dec	0.56	0.85	10	15
						Dissolved Copper (UG/L as CU)	********	********	23.1	23.1
						DO	*********	*********	*********	*********
						E.COLI	********	********	126	*********
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9

Facility Name	Permit No.	Major/Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentration Avg.	Concentration Max.
						TKN, Jun-Dec	0.23	0.34	4.1	6.1
						TSS	1.7	2.5	30	45
						Dissolved Zinc (UG/L as ZN)	********	*********	148.6	148.6

APPENDIX C

Discharge Monitoring Reports (DMR) from Individual Permitted Facilities within the Jackson River Watershed

Figure C-1: Alleghany Moore STP Effluent Flow Values

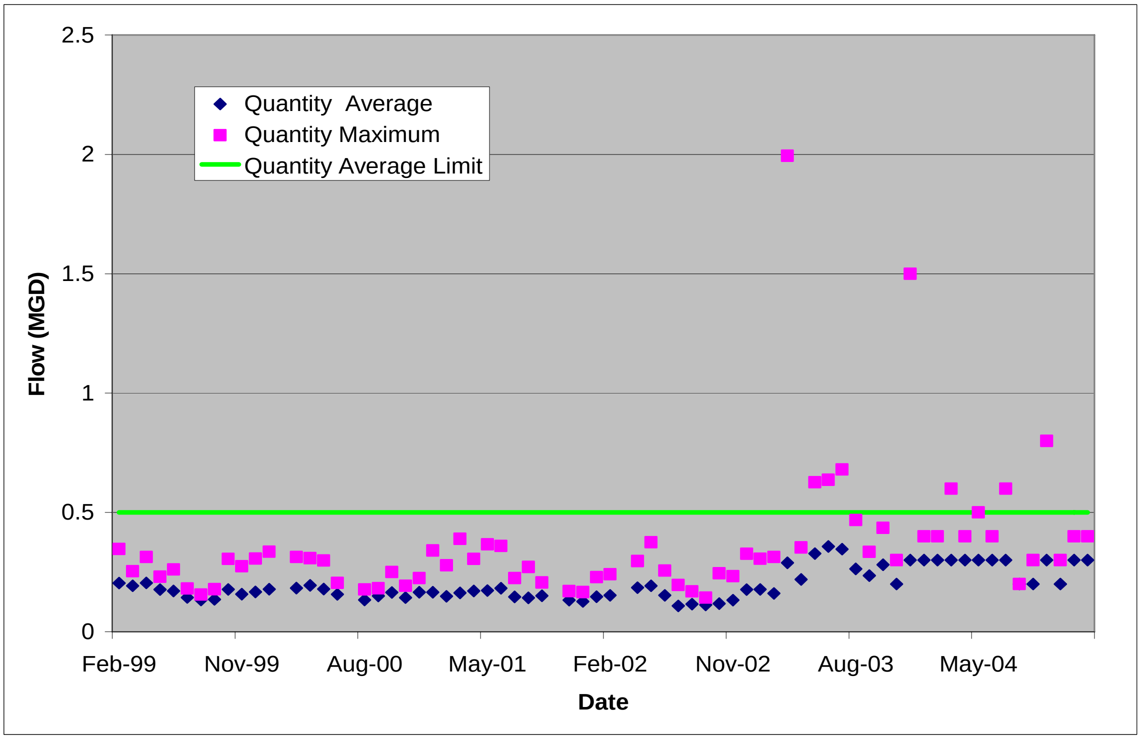


Figure C-2: Alleghany Moore STP Effluent BOD5 Quantities

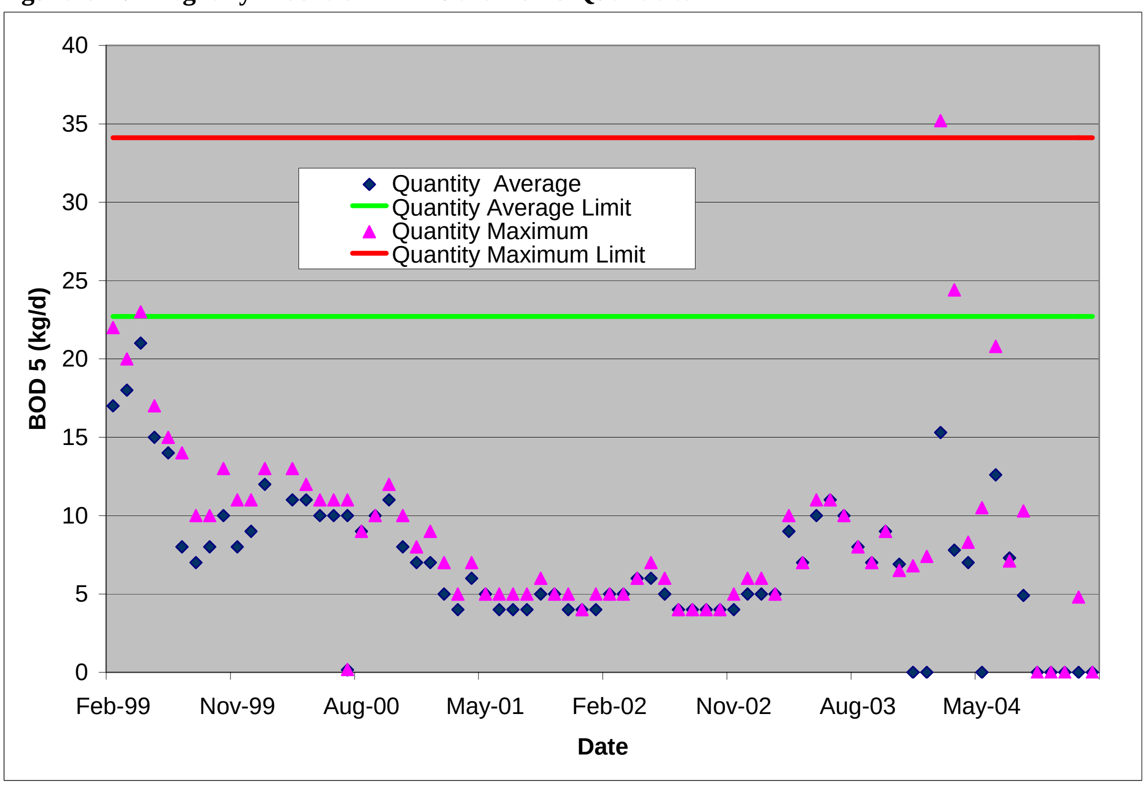


Figure C-3: Alleghany Moore STP Effluent BOD5 Concentrations

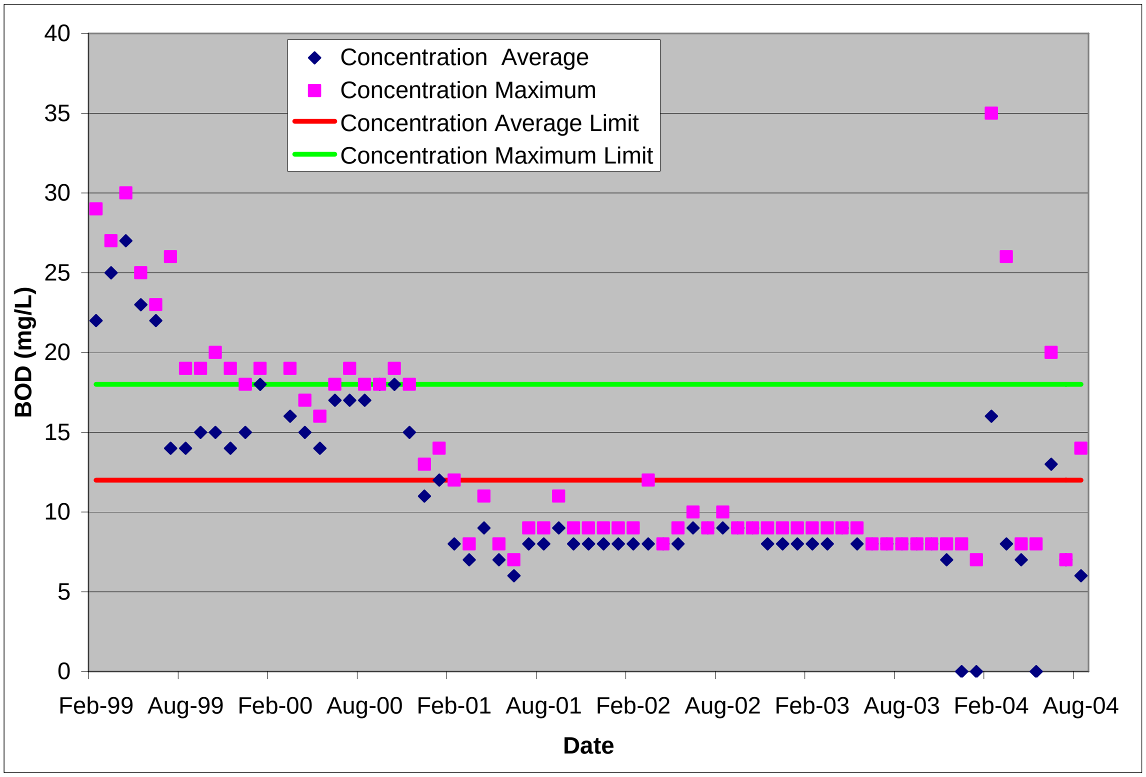


Figure C-4: Alleghany Moore STP Effluent Cl2 Concentrations

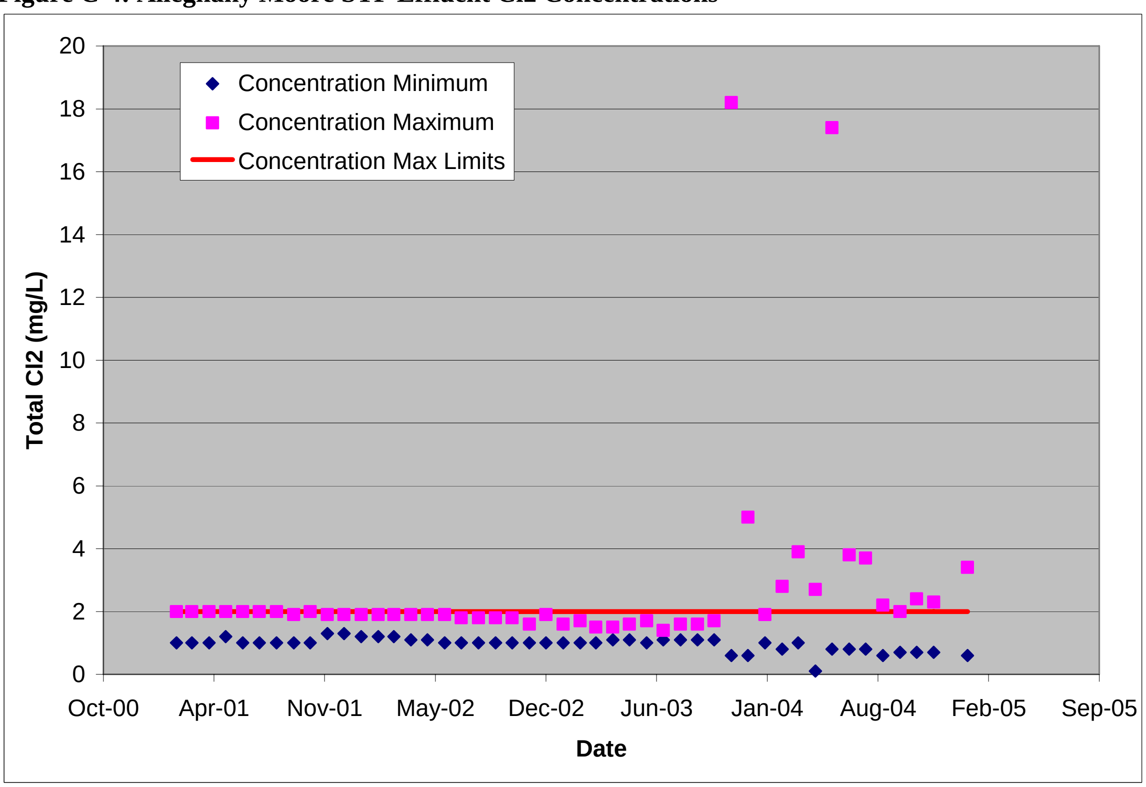


Figure C-5: Alleghany Moore STP Effluent Dissolved Oxygen Concentrations

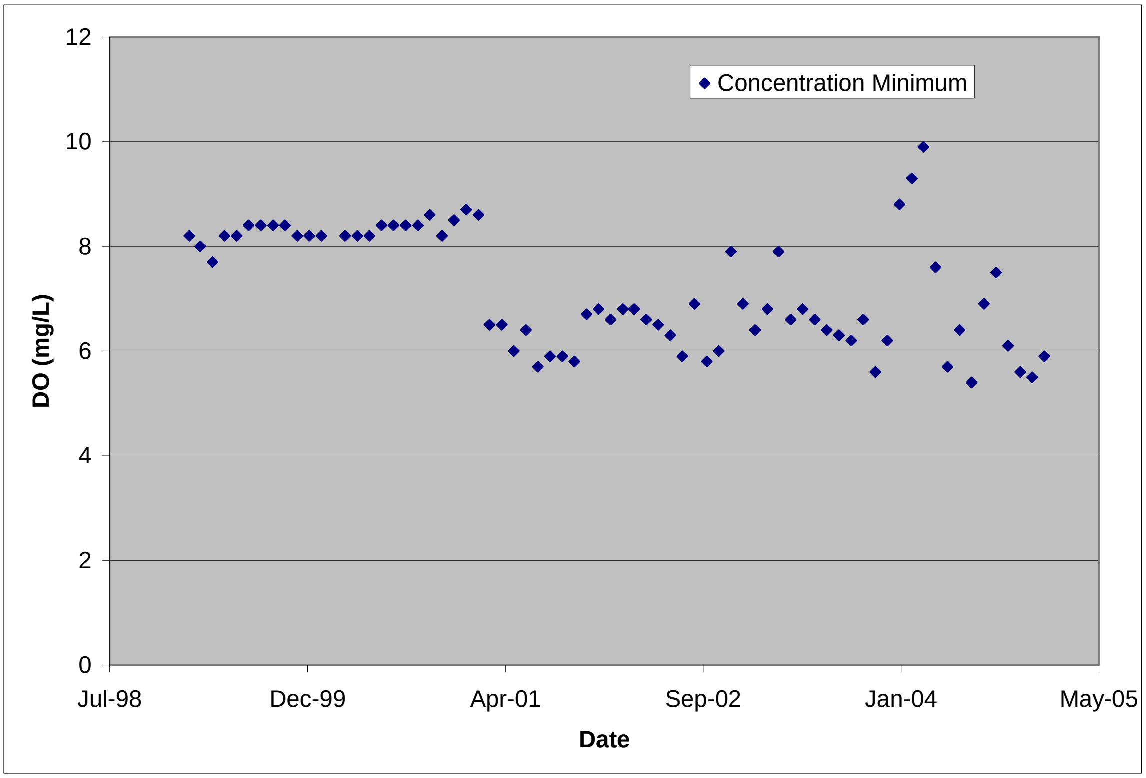


Figure C-6: Alleghany Moore STP Effluent TSS Quantities

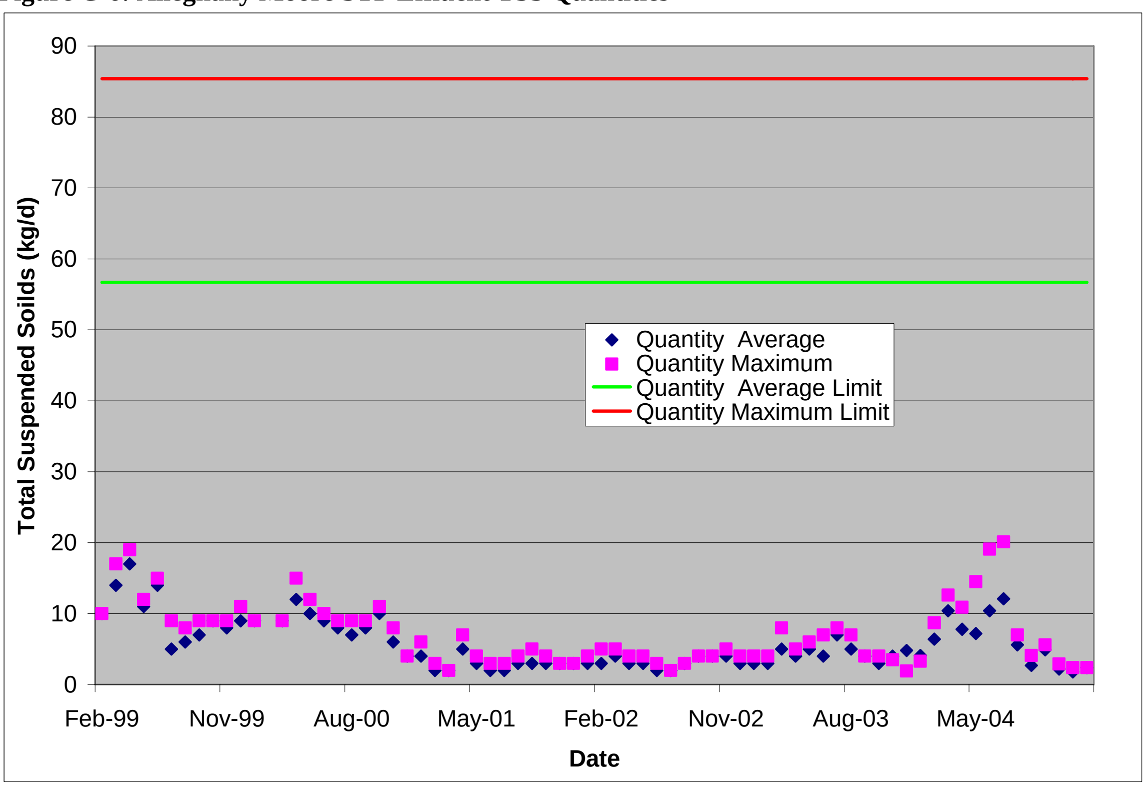


Figure C-7: Alleghany Moore STP Effluent TSS Concentrations

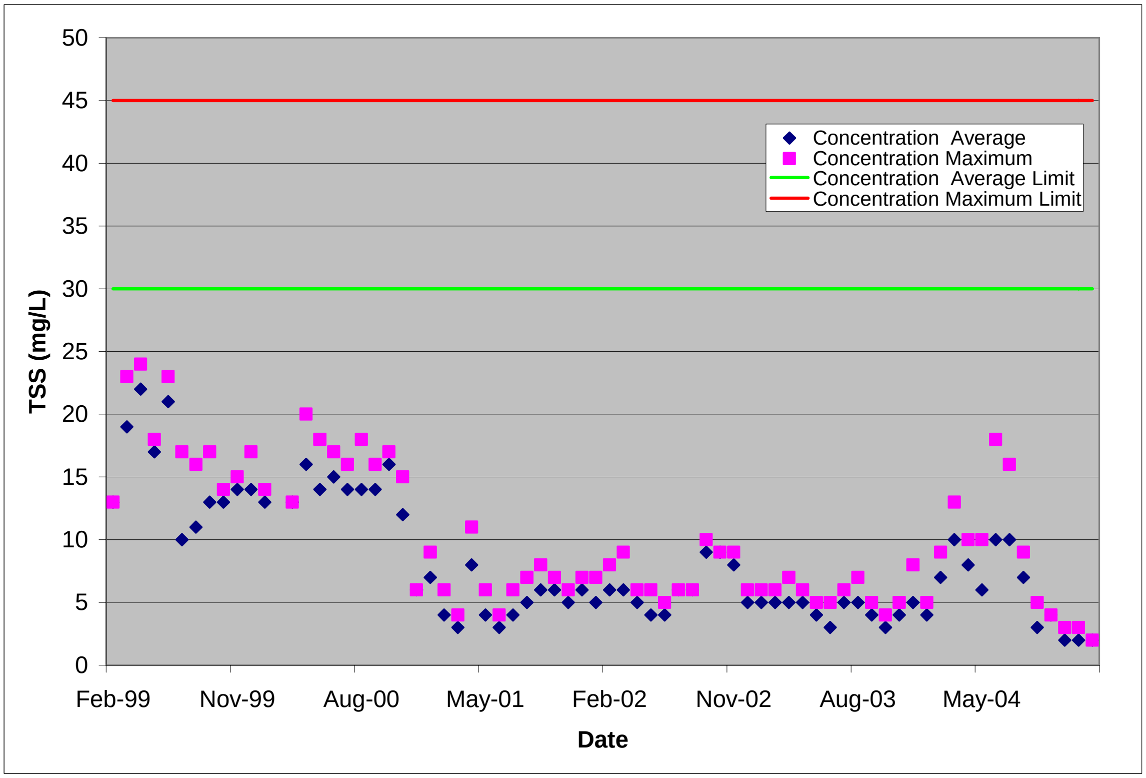


Figure C-8: Applied Extrusion Technologies Effluent Flow Data from Outfall 1

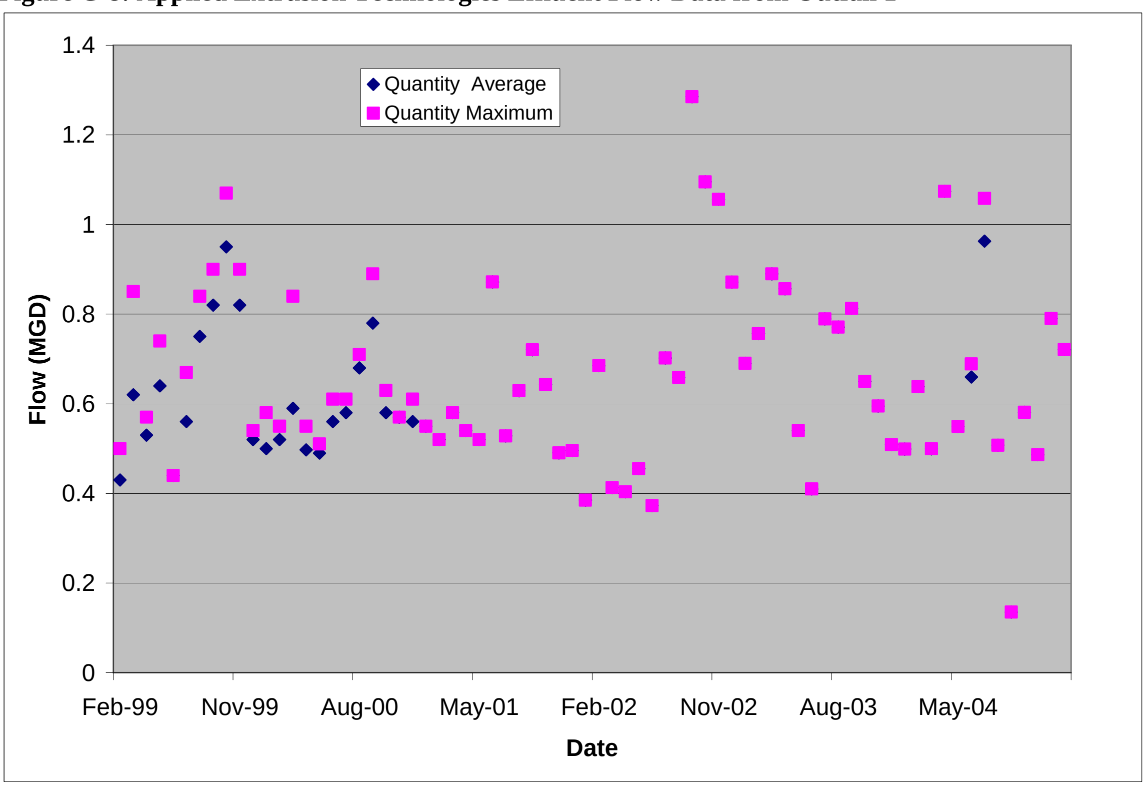


Figure C-9: Applied Extrusion Technologies Effluent TSS Concentrations from Outfall 1

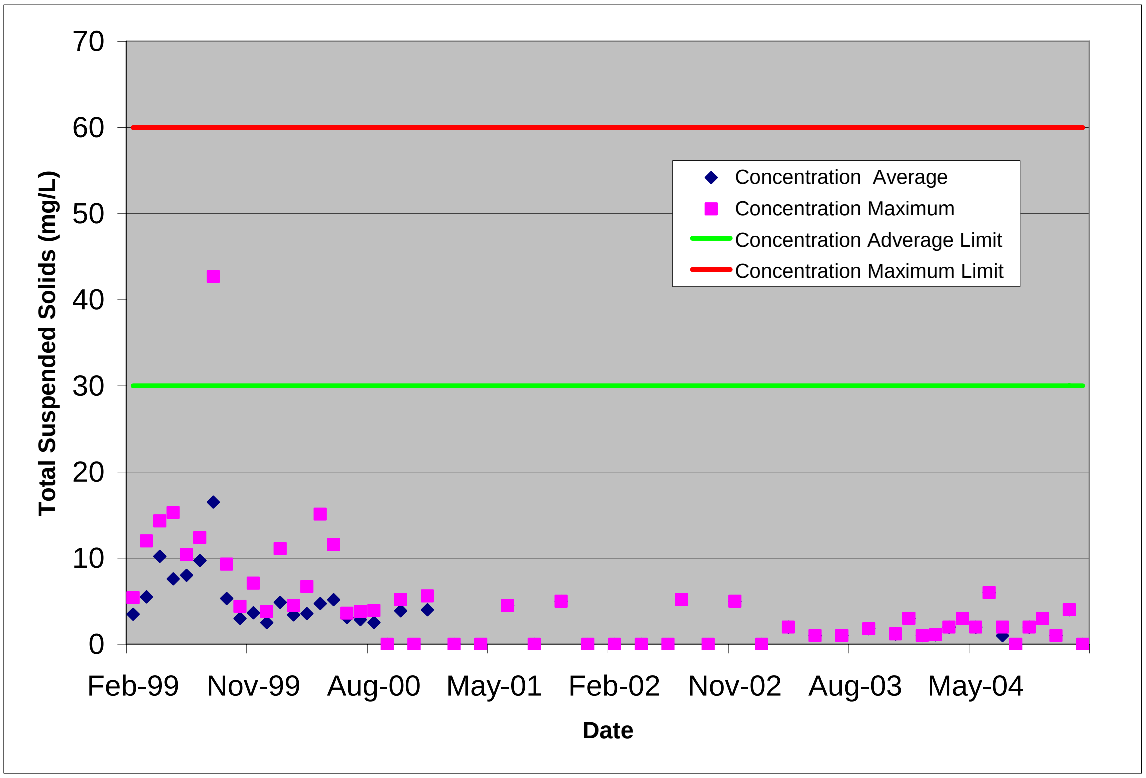


Figure C-10: Applied Extrusion Technologies Effluent Temperature Values from Outfall 1

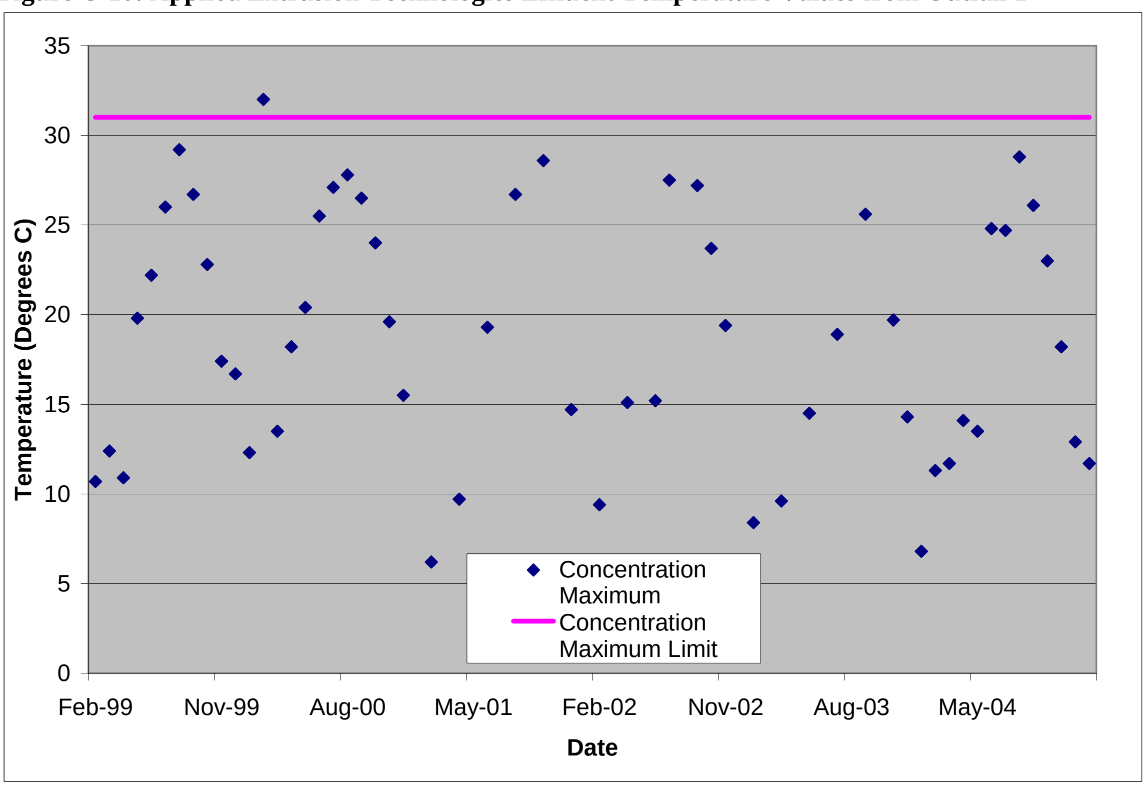


Figure C-11 Applied Extrusion Technologies Effluent pH Values from Outfall 1

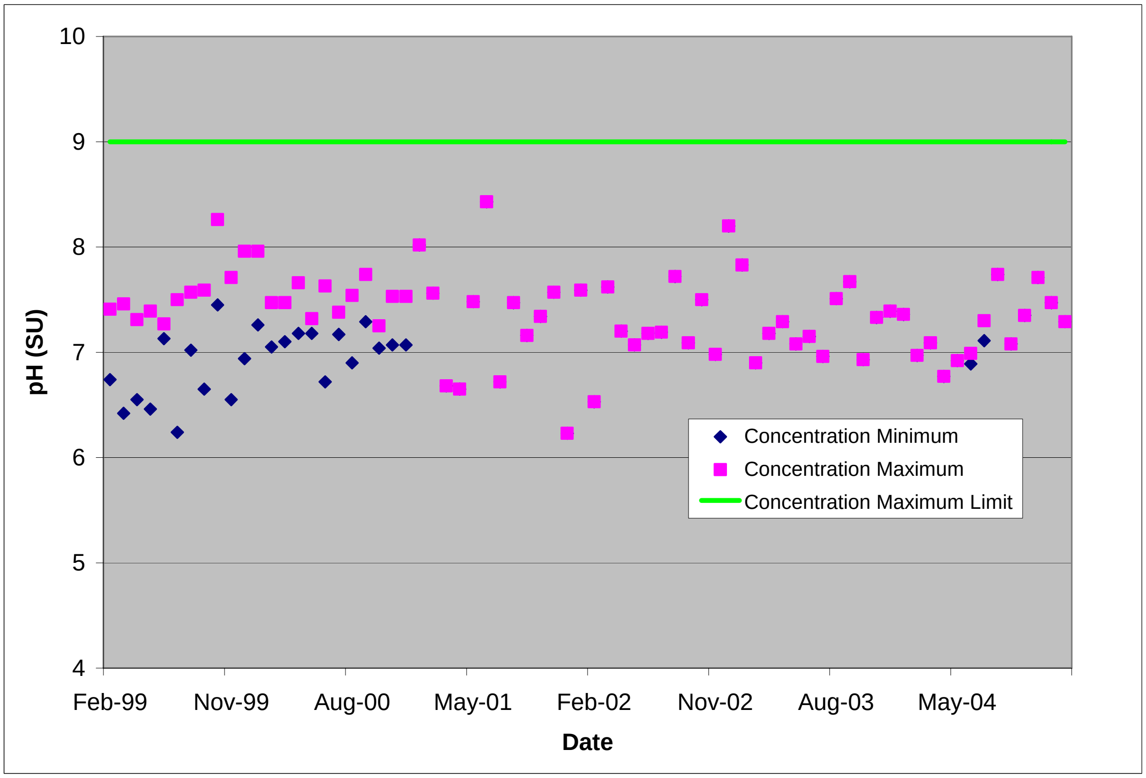


Figure C-12: Applied Extrusion Technologies Effluent BOD5 Quantities from Outfall 1

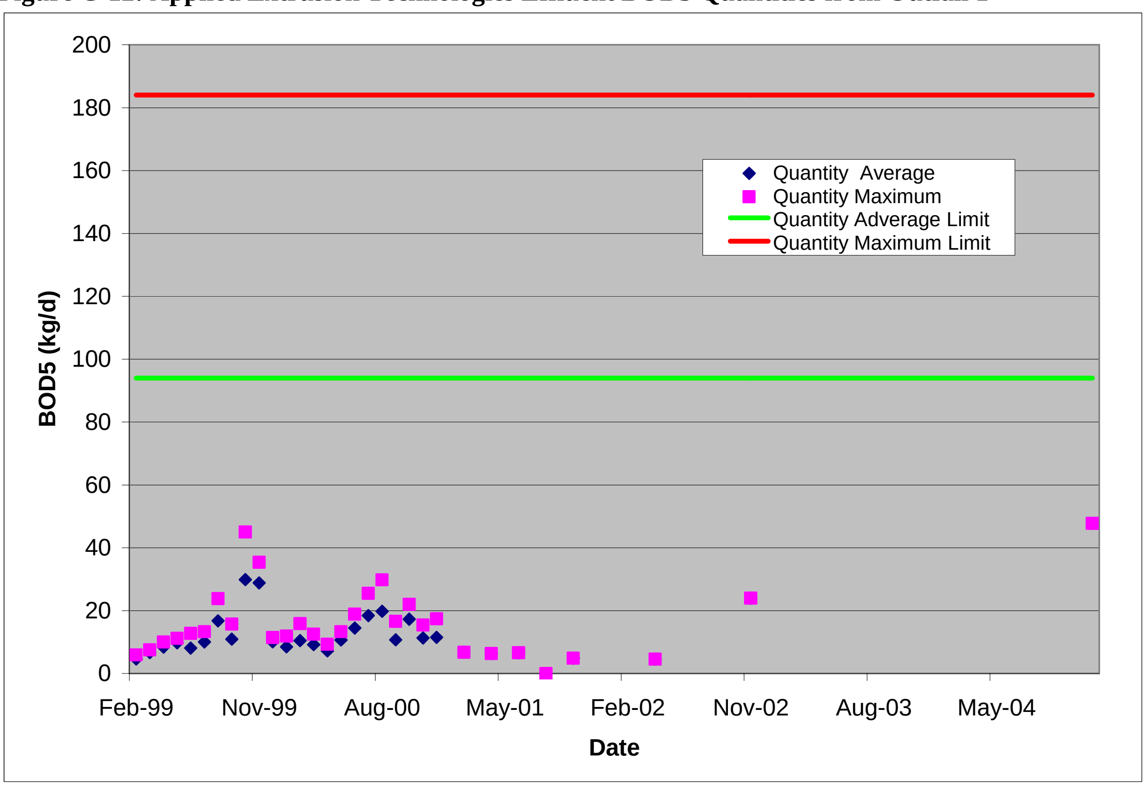


Figure C-13: Applied Extrusion Technologies Effluent Flow Values from Outfall 2

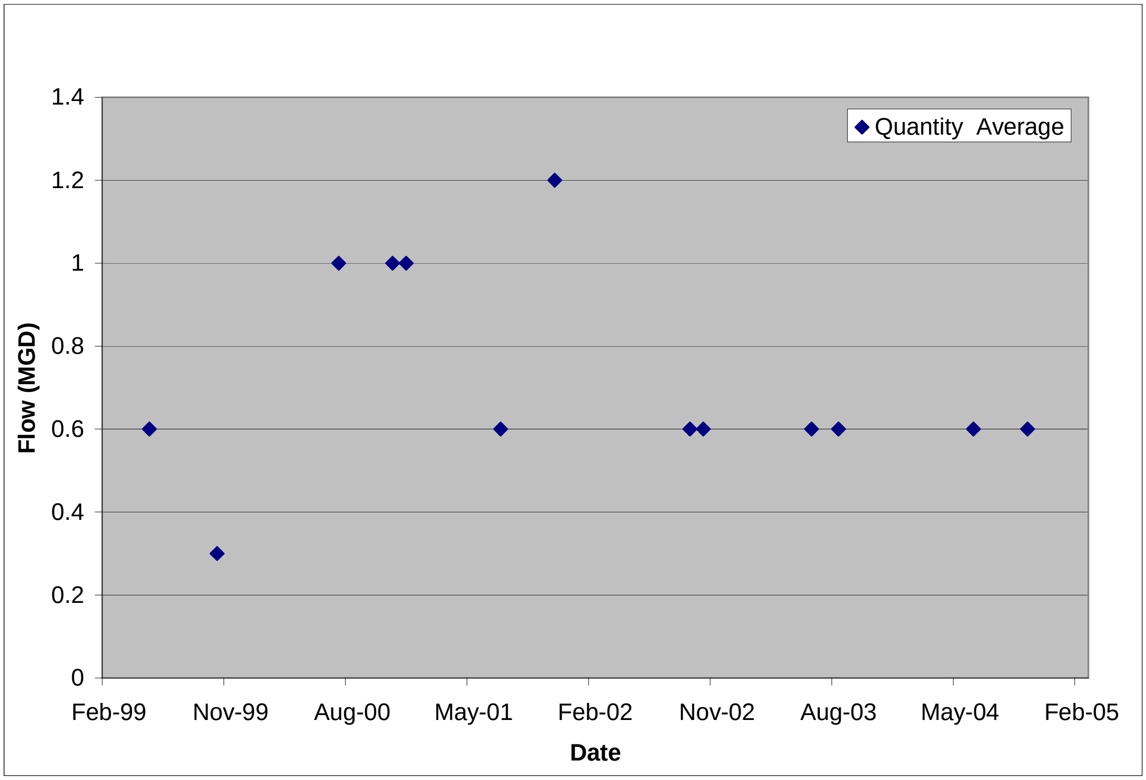


Figure C-14: Applied Extrusion Technologies Effluent TSS Concentrations from Outfall 2

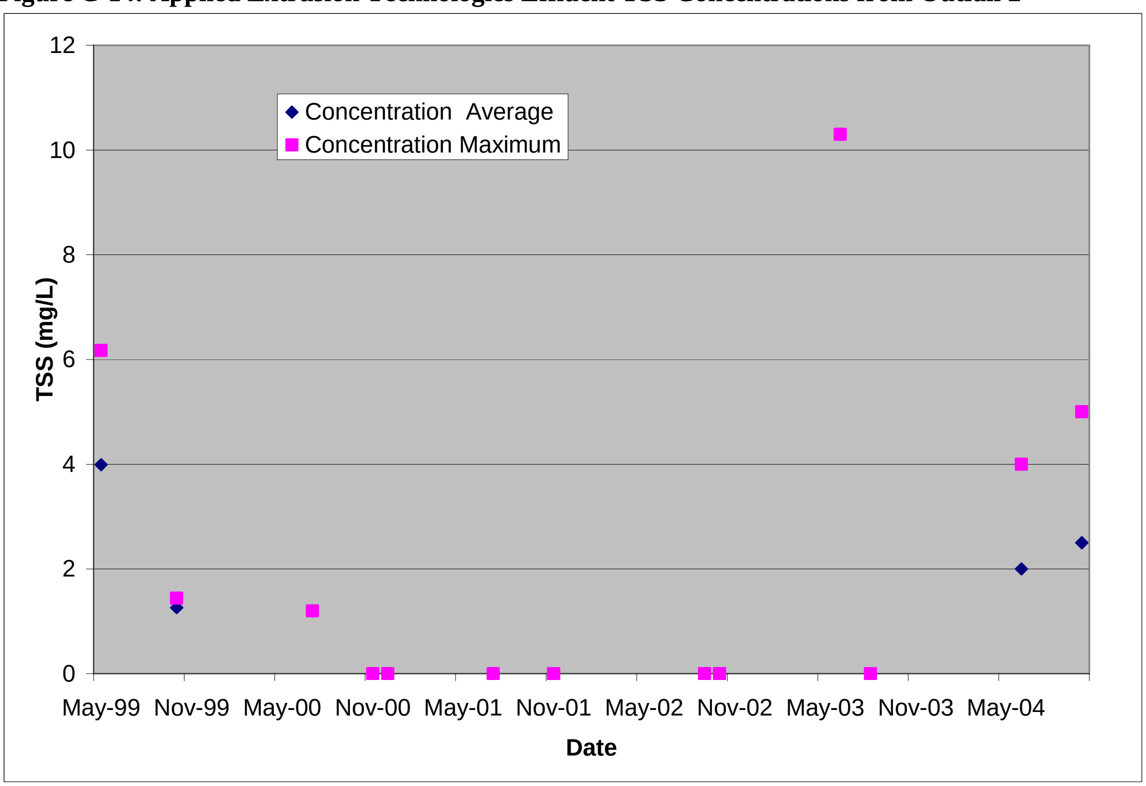


Figure C-15: Applied Extrusion Technologies Effluent Flow Values from Outfall 103

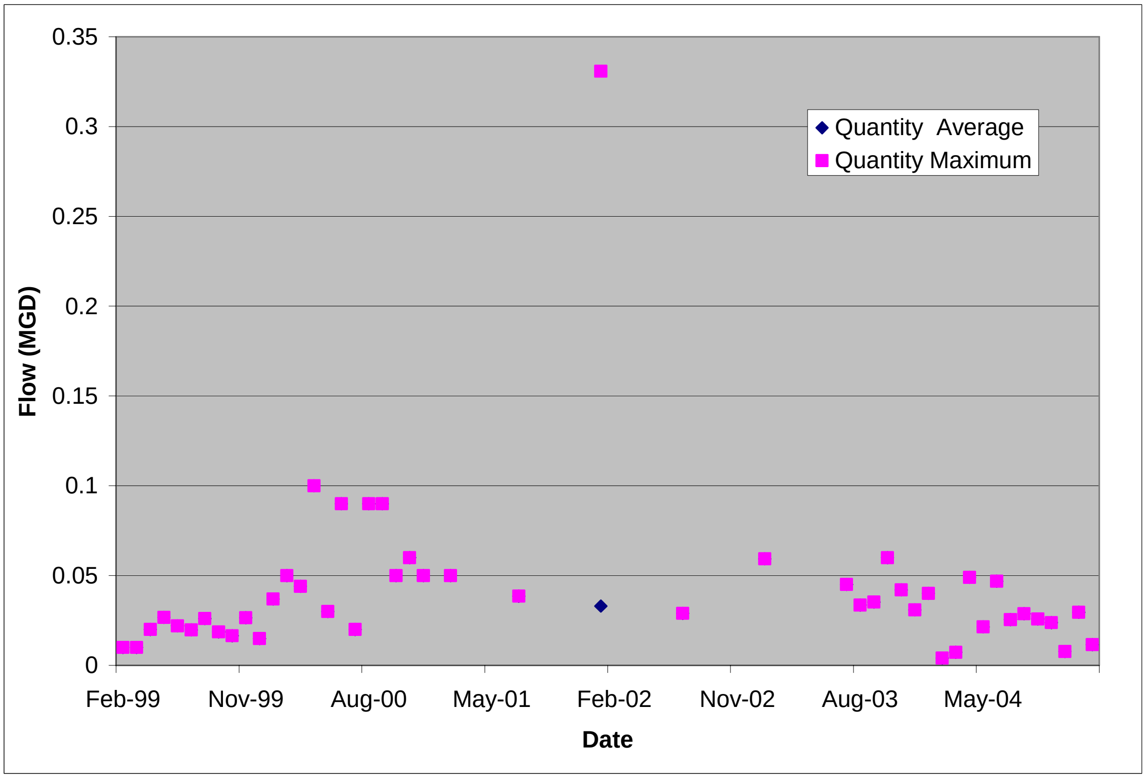


Figure C-16: Applied Extrusion Technologies Effluent TSS Quantities from Outfall 103

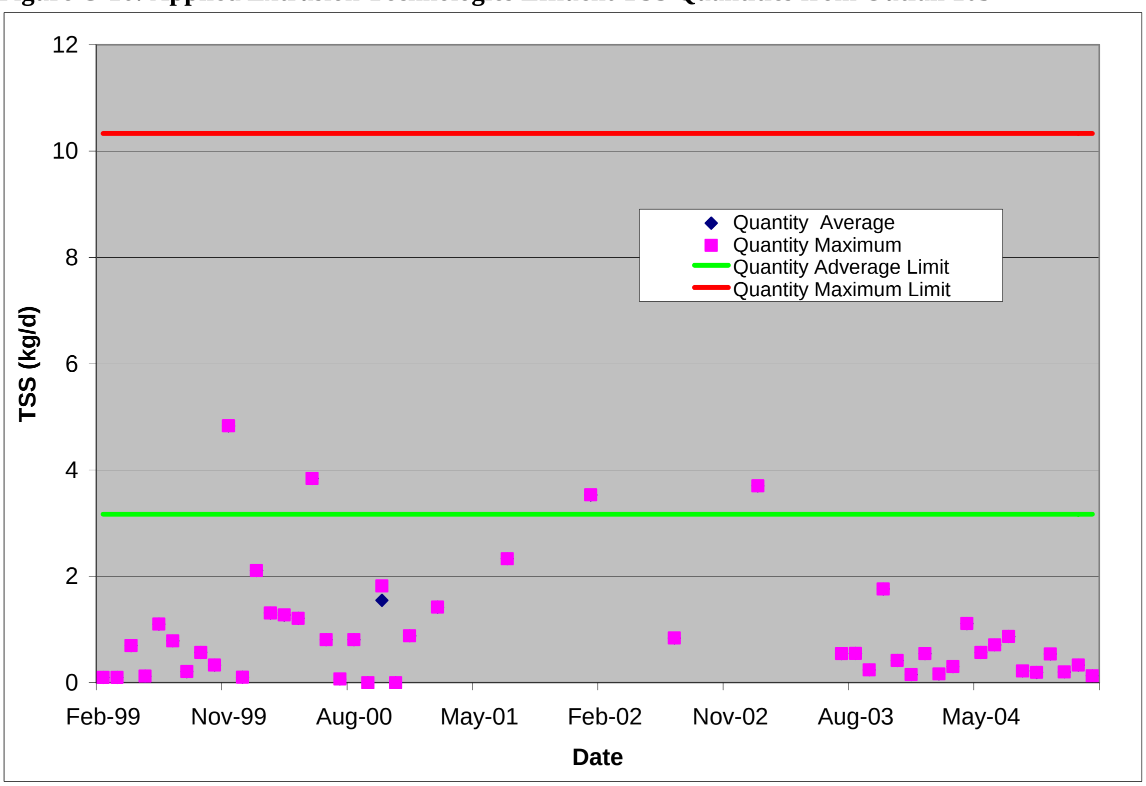


Figure C-17: Applied Extrusion Technologies Effluent BOD5 Quantities Outfall 103

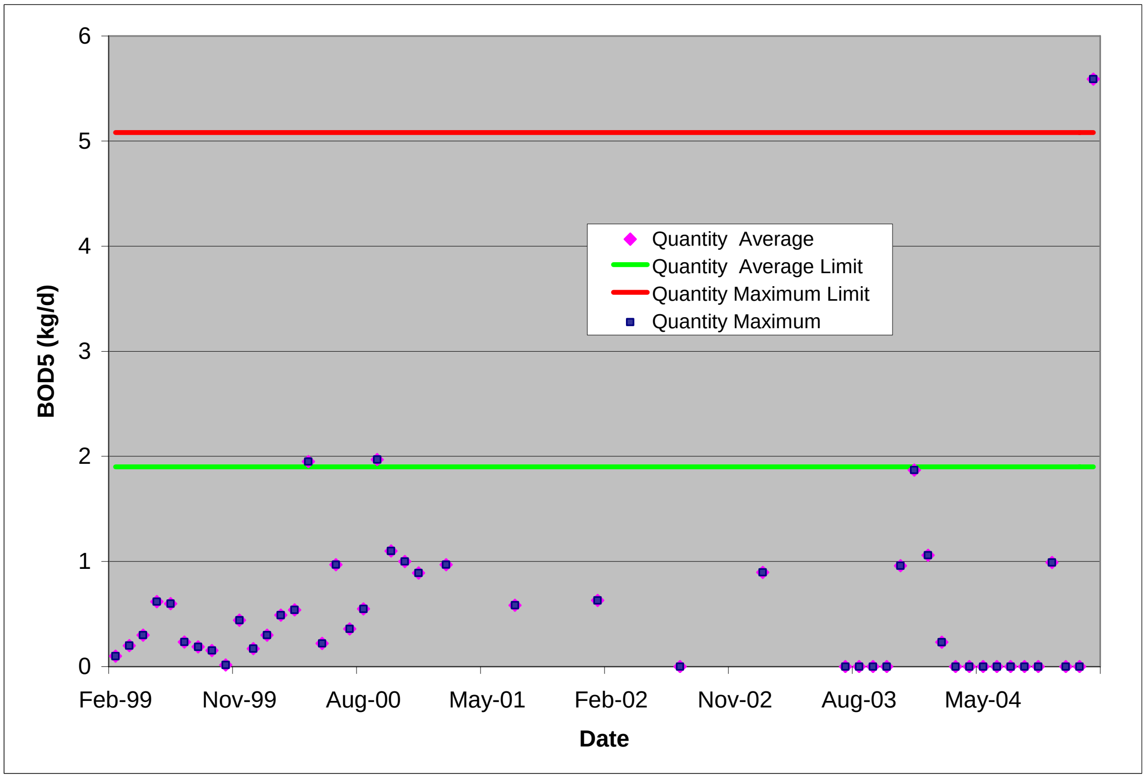


Figure C-18: Boys Home STP Effluent Flow Values

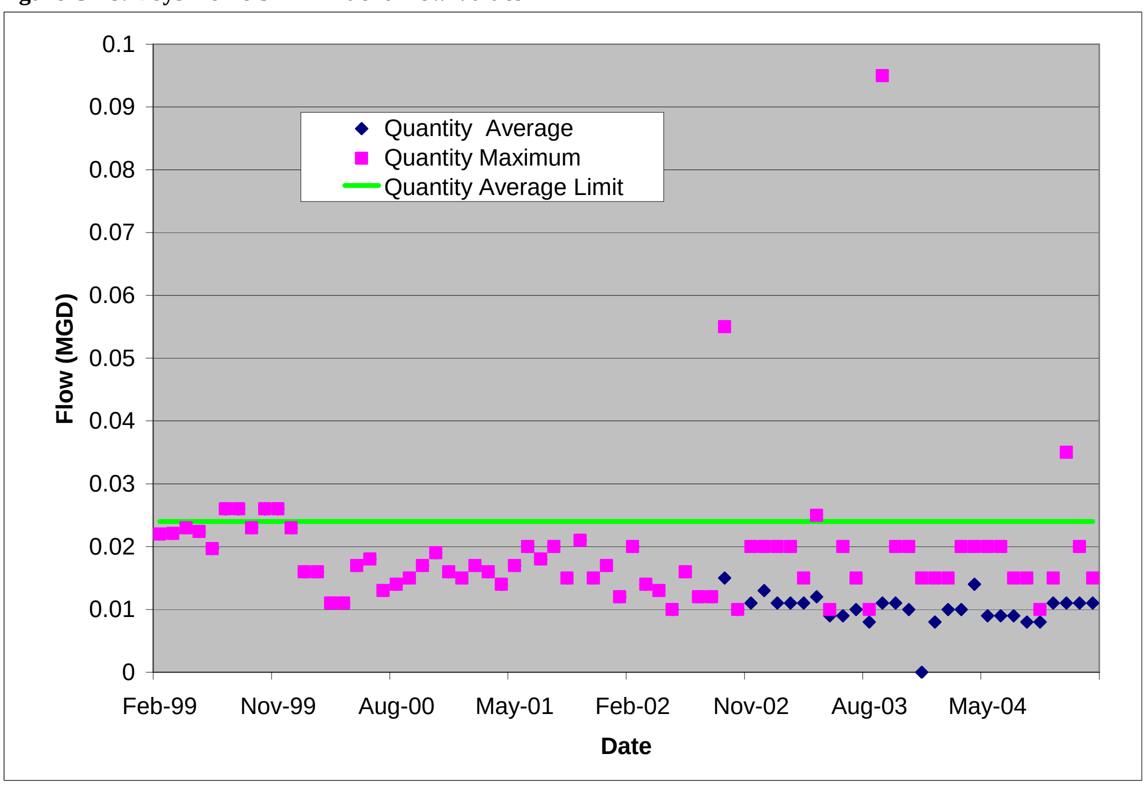


Figure C-19: Boys Home STP Effluent pH Values

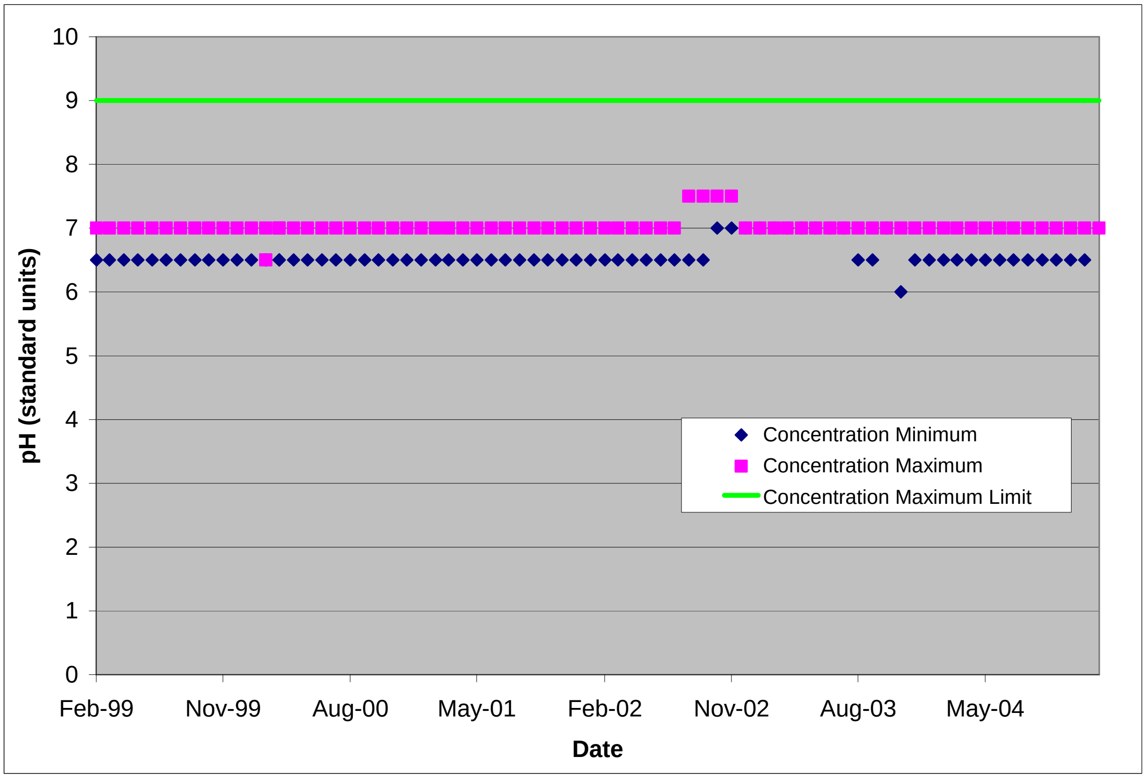


Figure C-20: Boys Home STP Effluent TSS Quantities

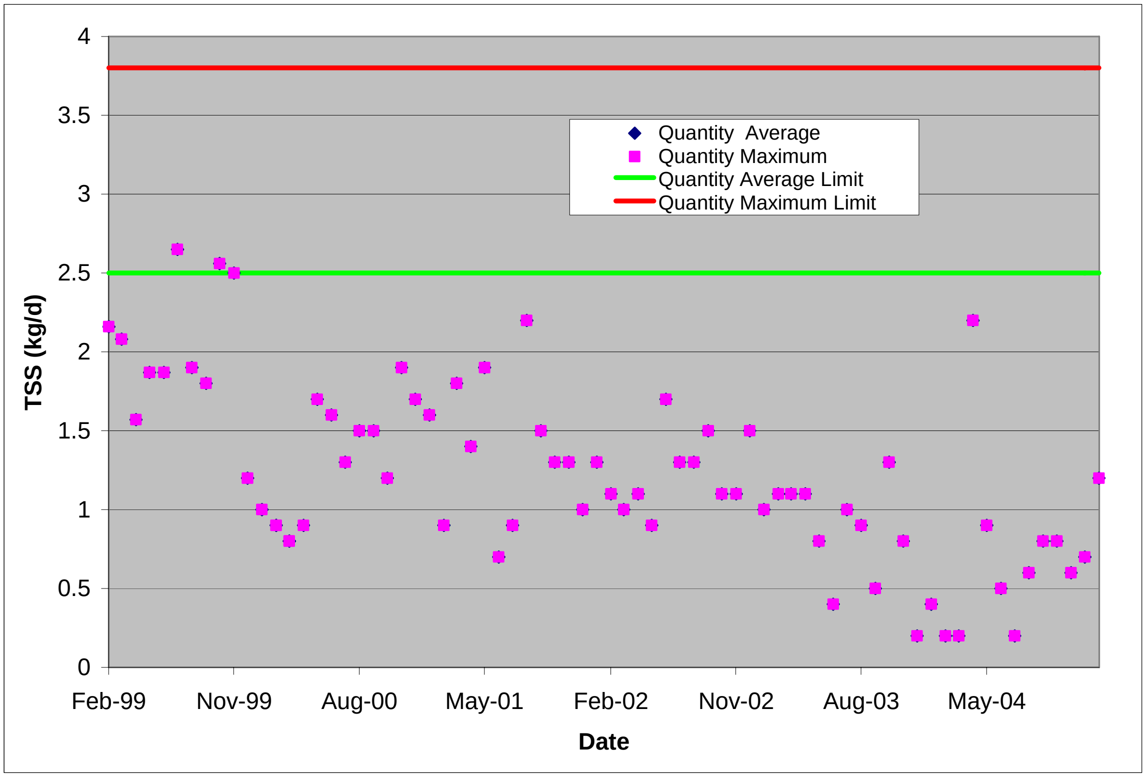


Figure C-21: Boys Home STP Effluent TSS Concentrations

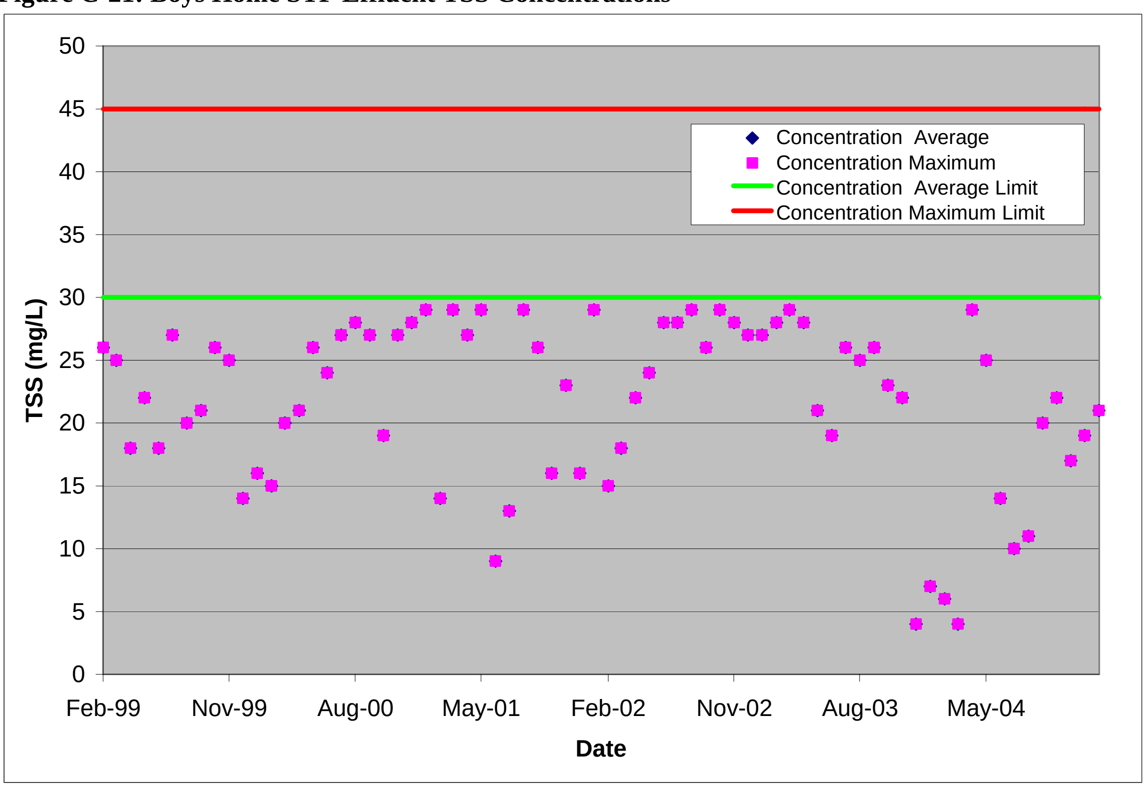


Figure C-22: Boys Home STP Effluent Oil and Grease Concentrations

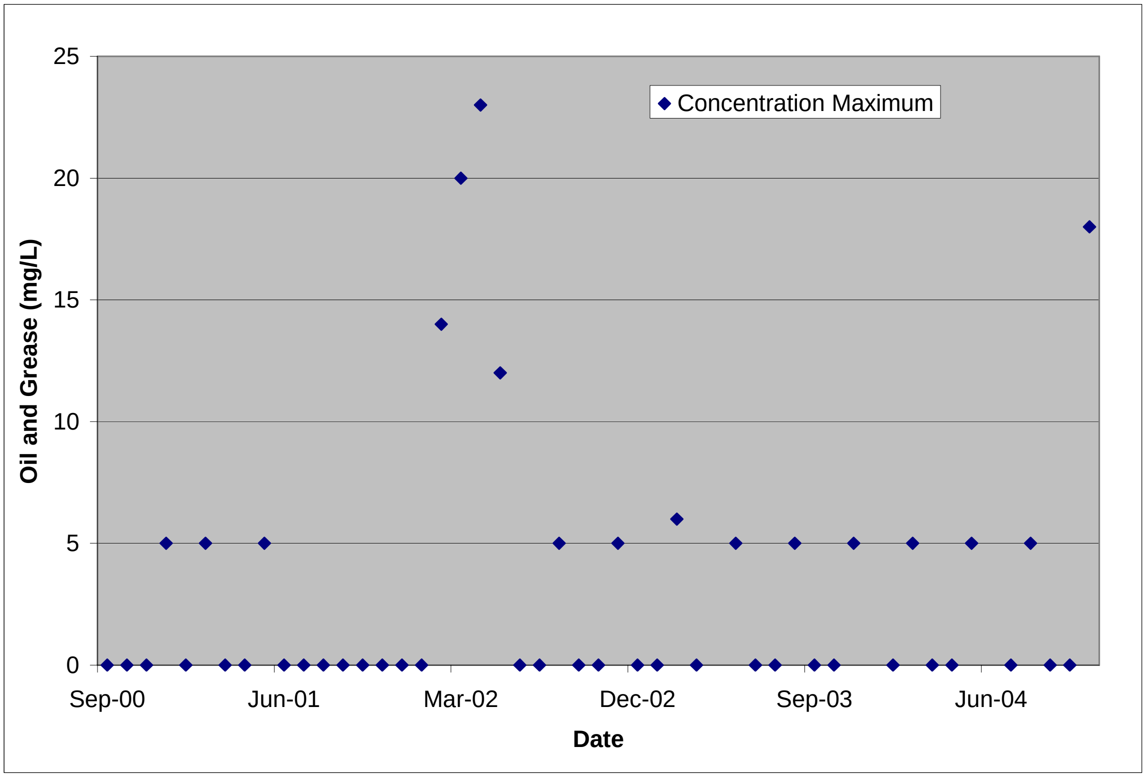


Figure C-23: Boys Home STP Effluent CL2 Concentrations

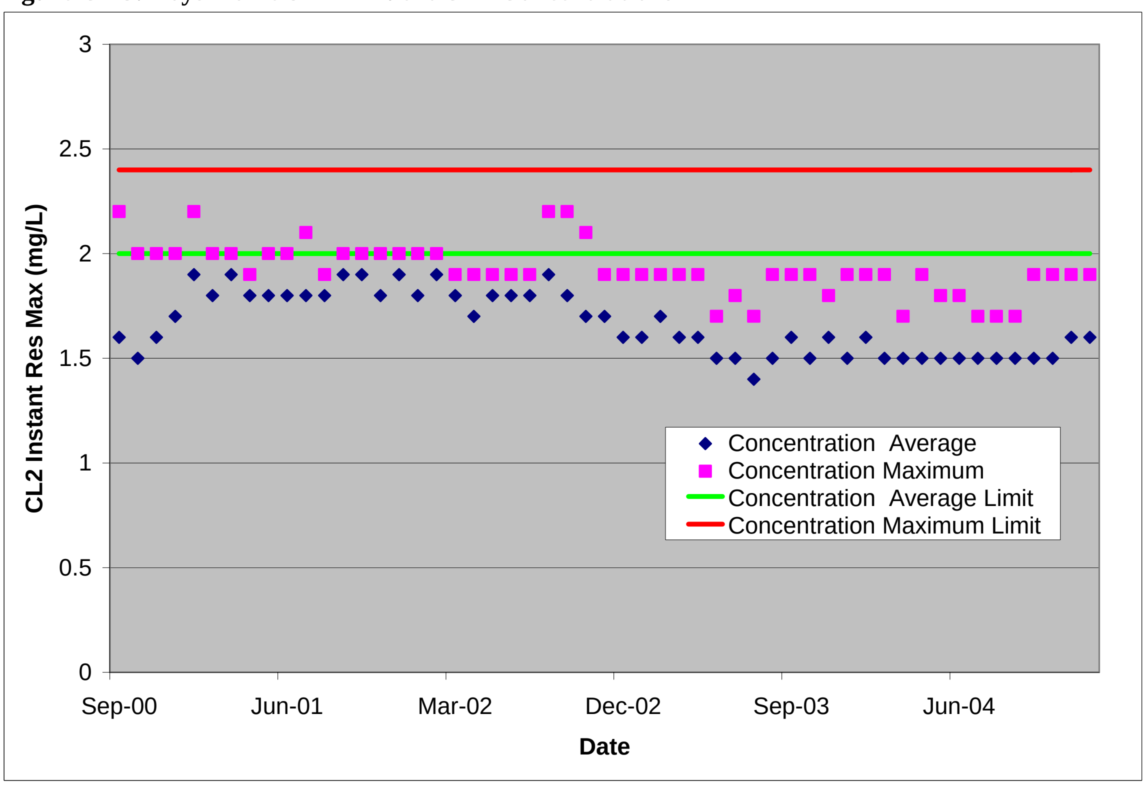


Figure C-24: Boys Home STP Effluent BOD5 Quantities

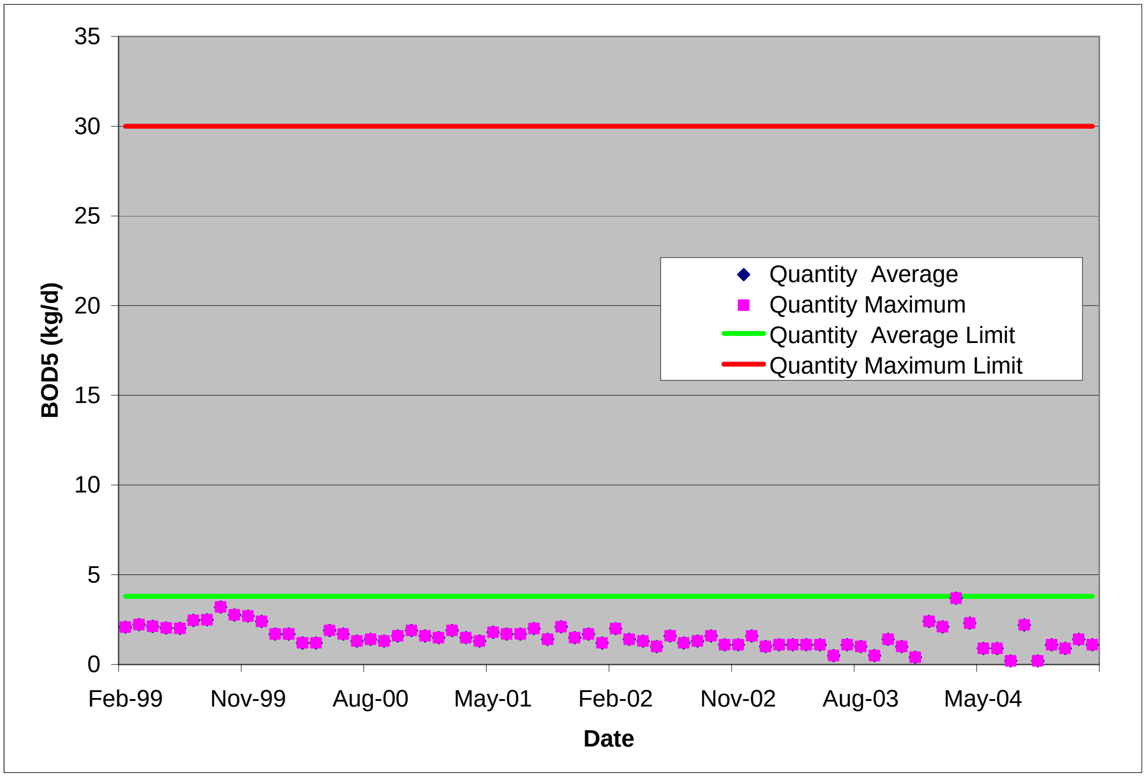


Figure C-25: Clifton Forge STP Effluent Flow Values

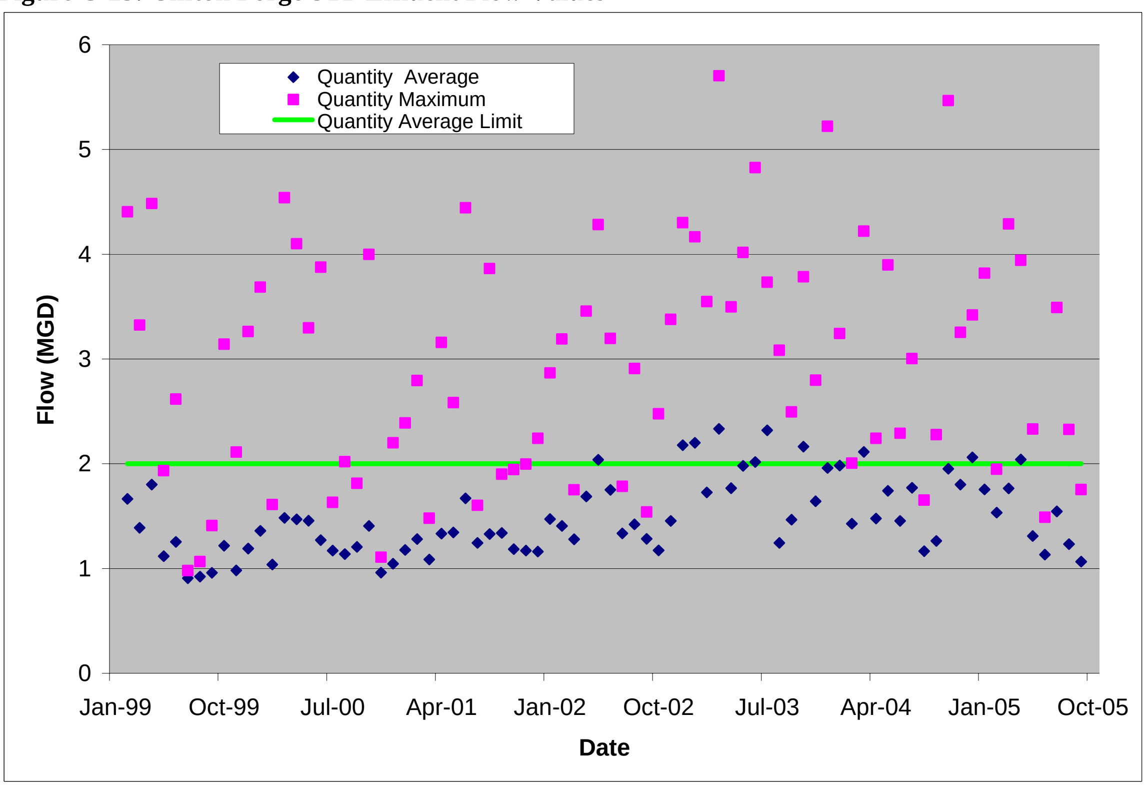


Figure C-26: Clifton Forge STP Effluent BOD5 Concentrations

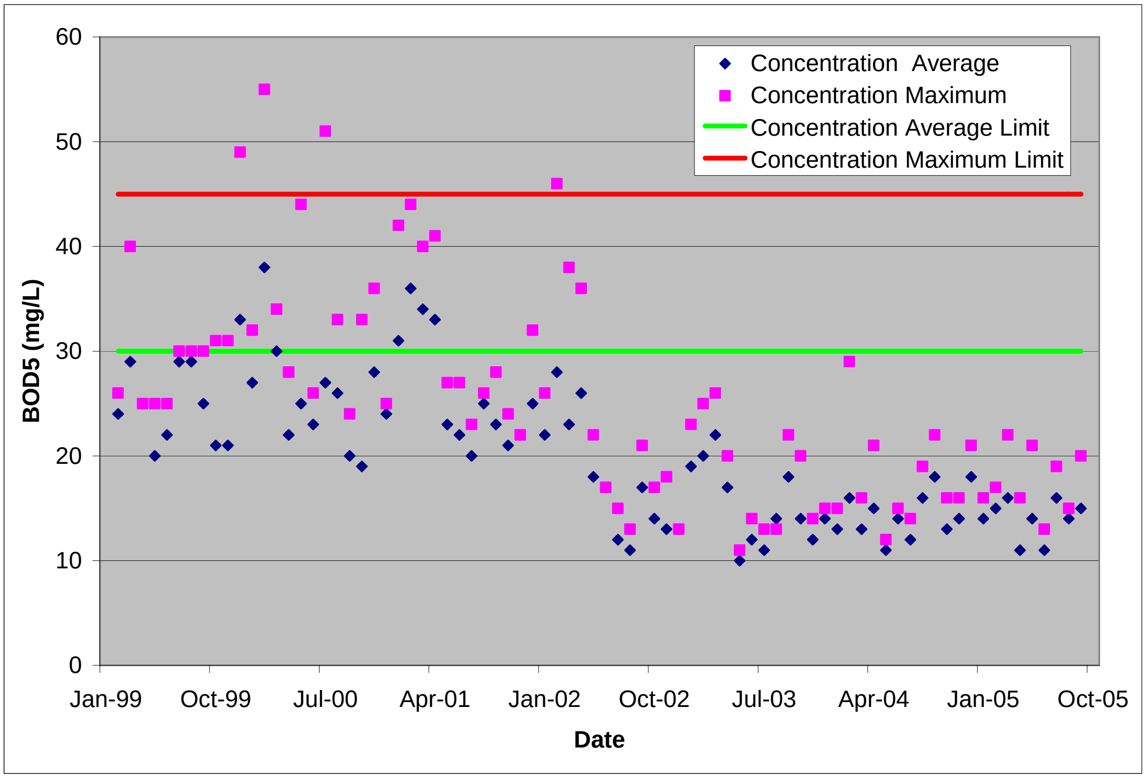


Figure C-27: Clifton Forge STP Effluent BOD5 Quantities

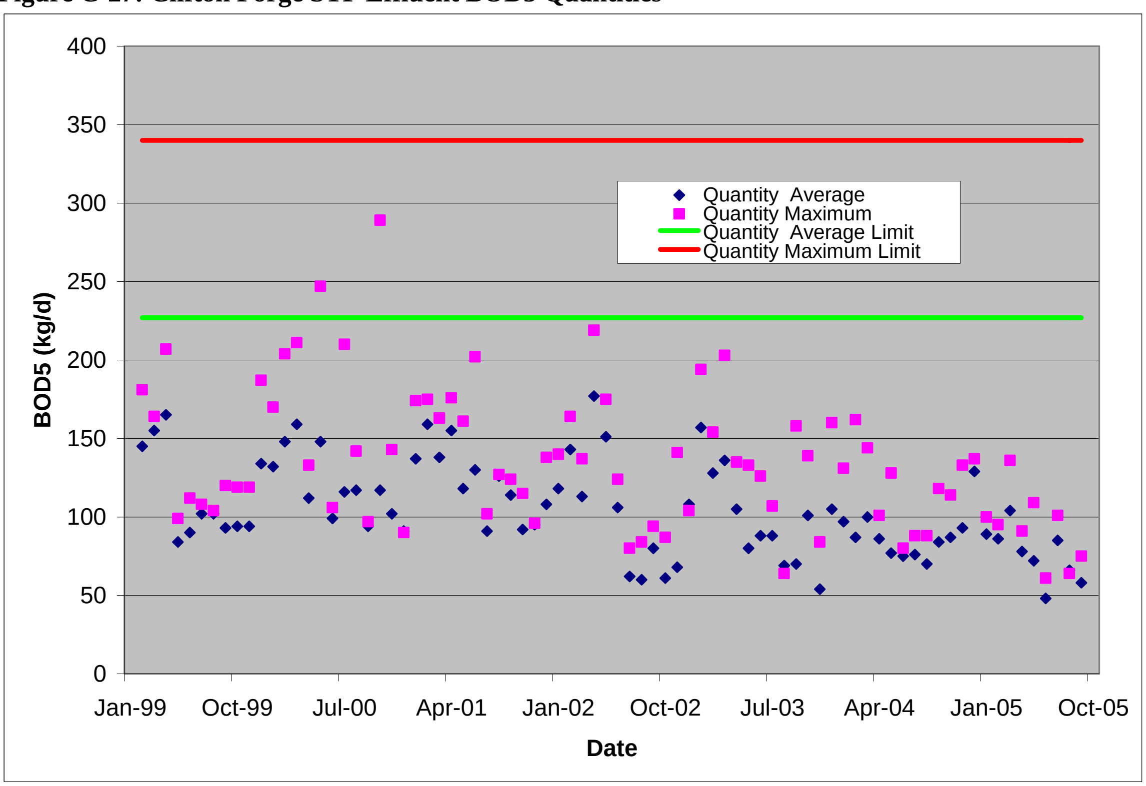


Figure C-28: Clifton Forge City STP Effluent CL2 Concentrations

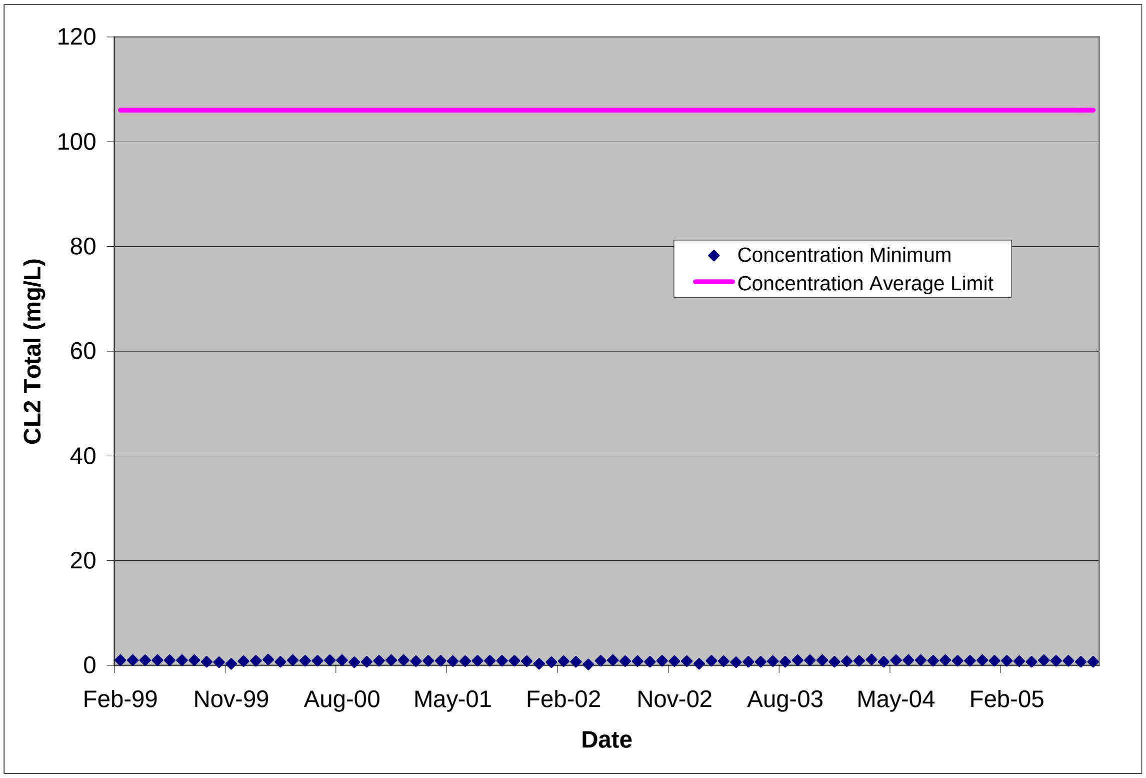


Figure C-29: Clifton Forge STP Effluent TSS Concentrations

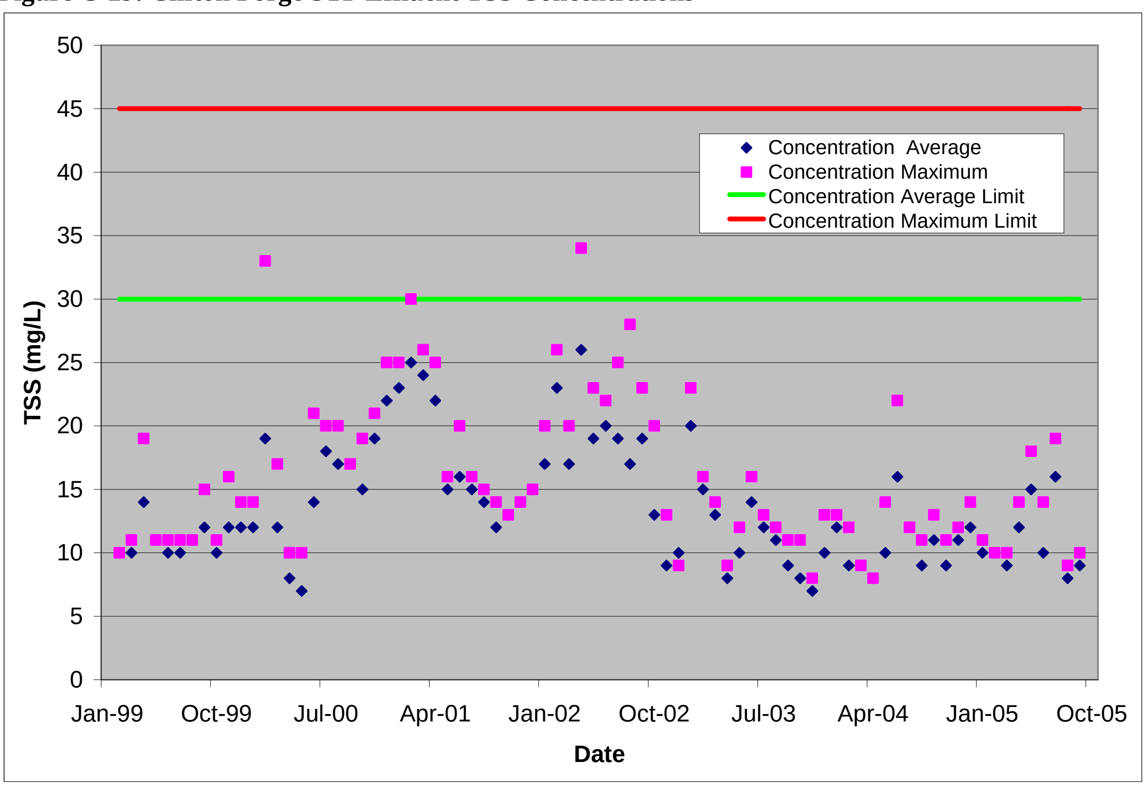


Figure C-30: Clifton Forge City STP Effluent TSS Quantities

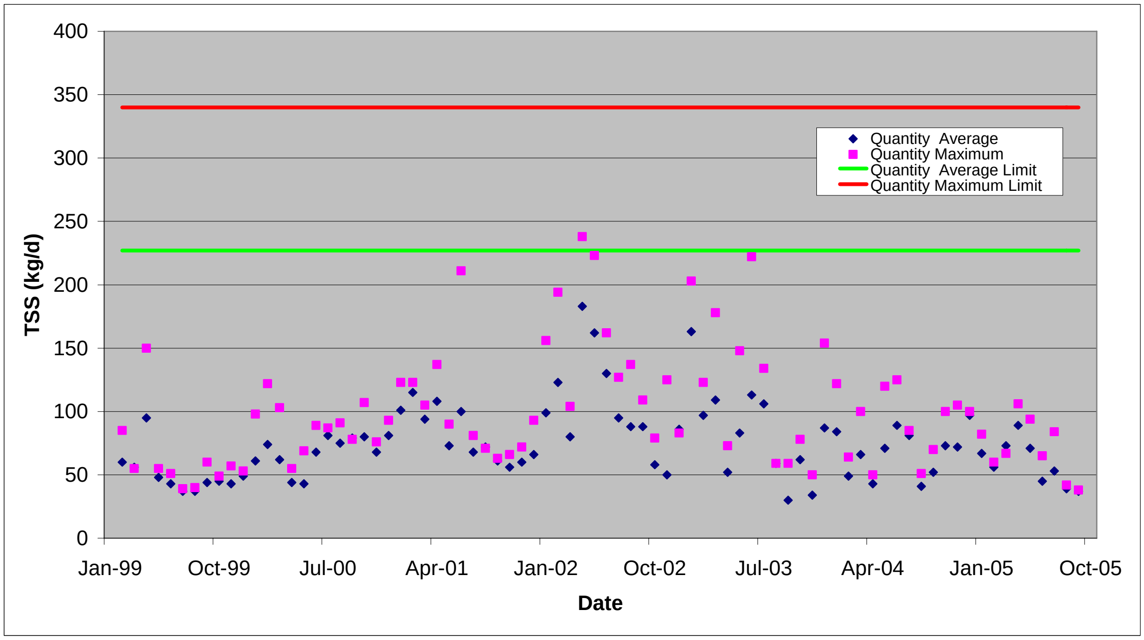


Figure C-31: Clifton Forge WTP Effluent Total Nitrogen as N Concentrations

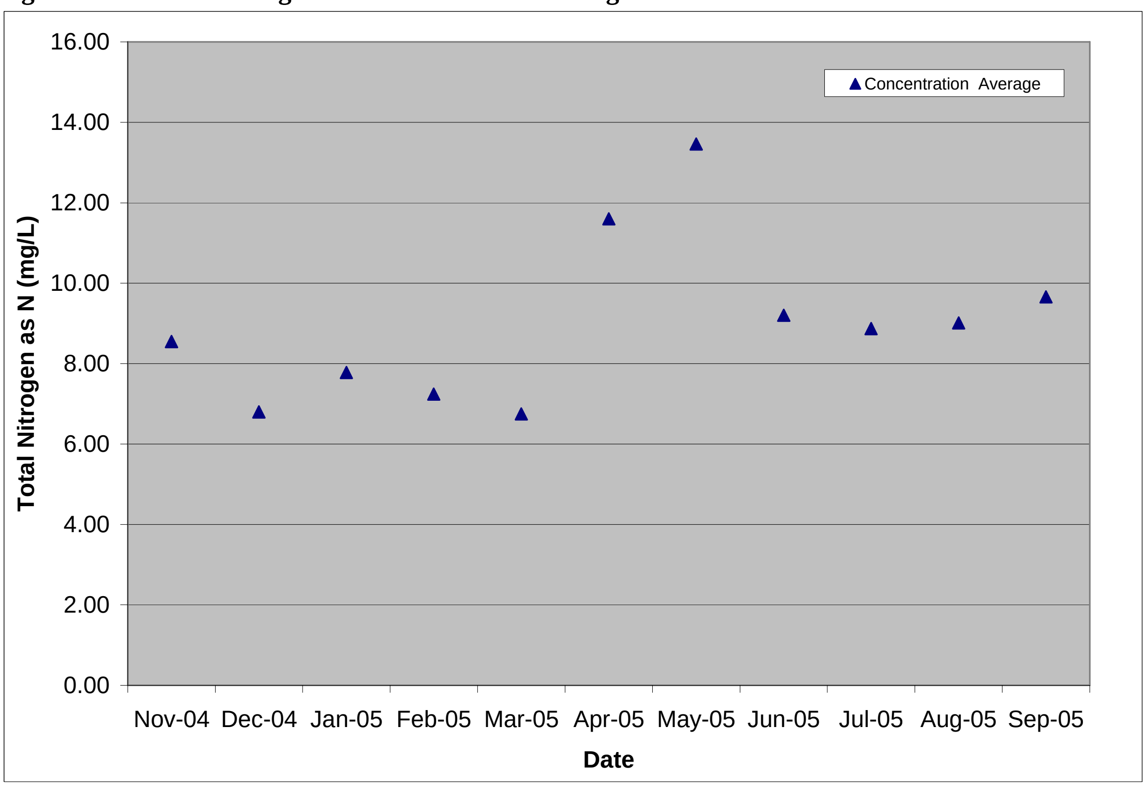


Figure C-32: Clifton Forge City STP Effluent Total Nitrogen as N Quantities

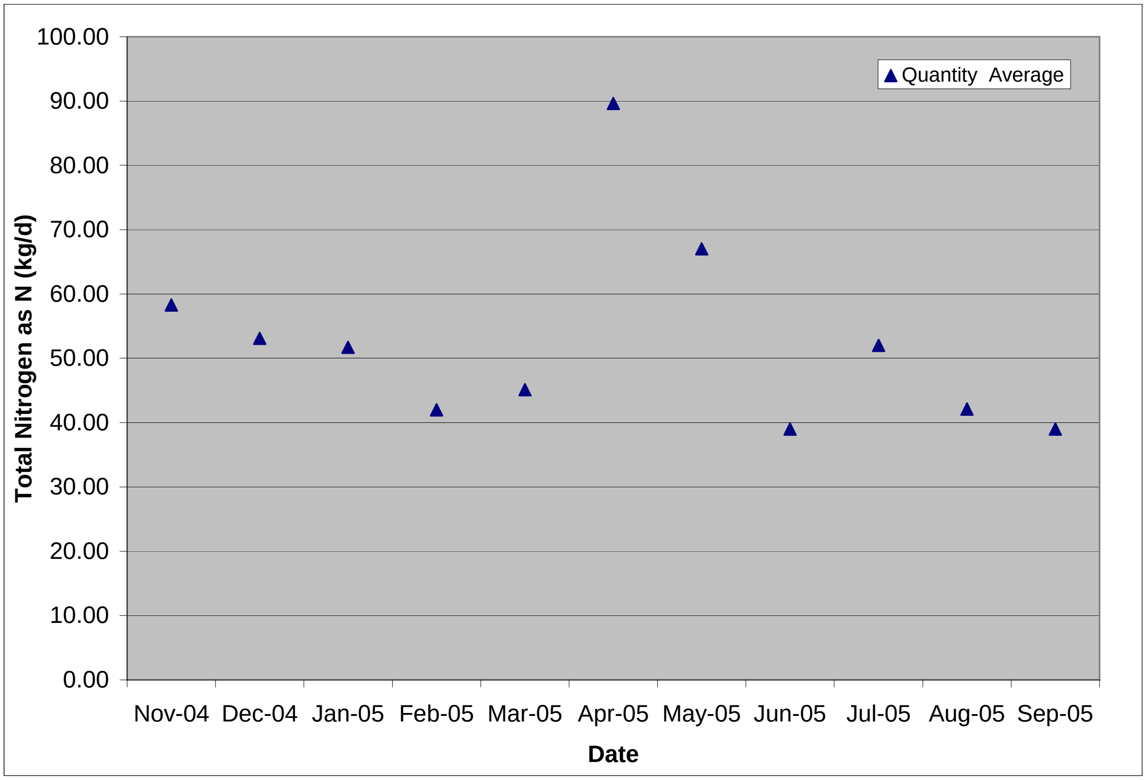


Figure C-33: Clifton Forge WTP Effluent Total Phosphorus as P Concentrations

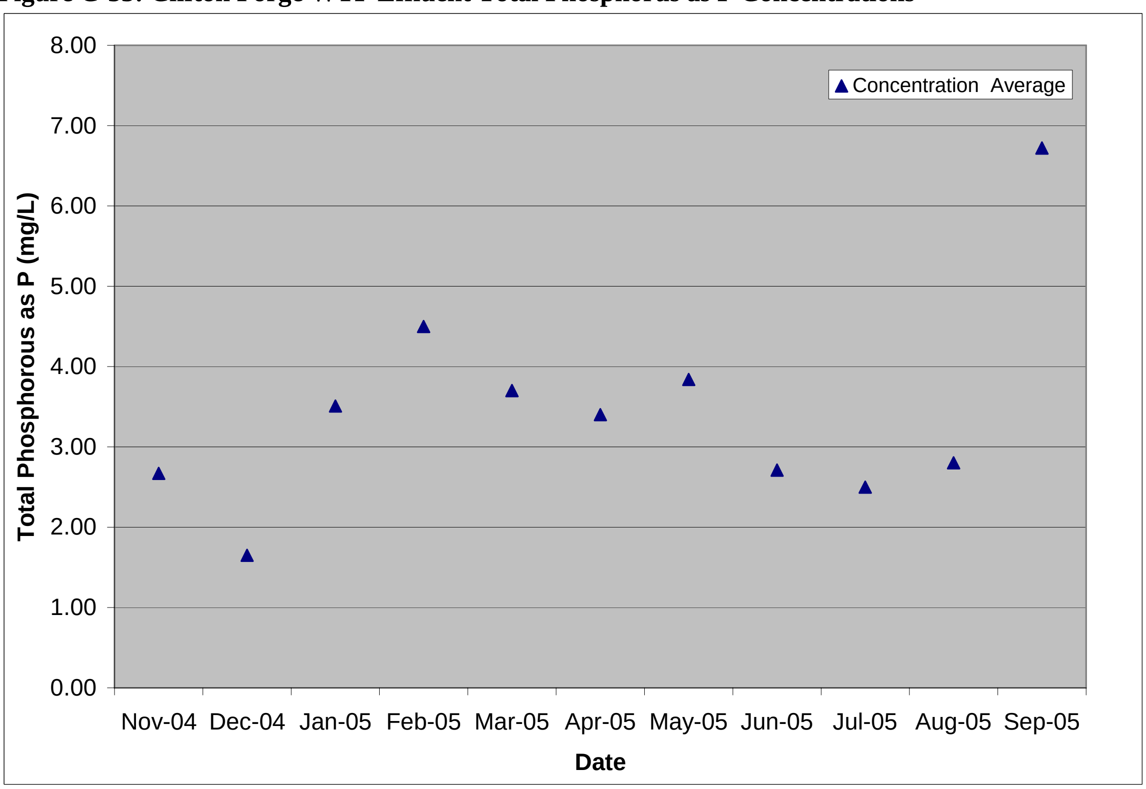


Figure C-34: Clifton Forge City STP Effluent Total Phosphorus as P Quantities

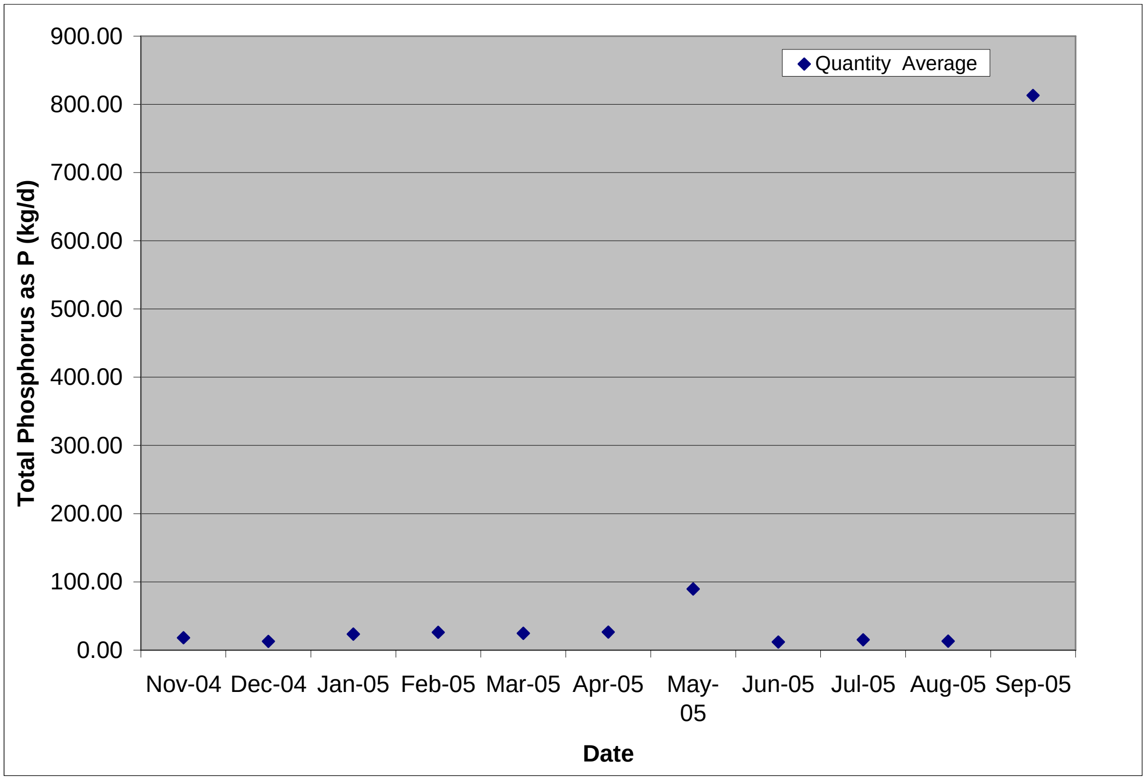


Figure C-35: Clifton Forge WTP Effluent pH Values

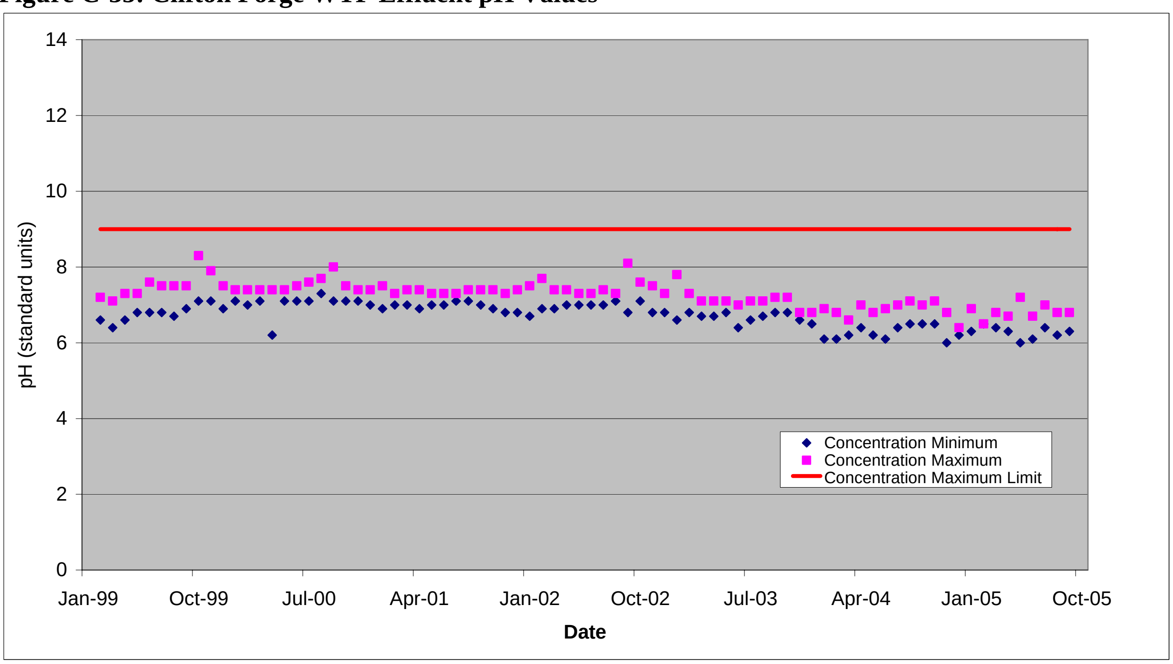


Figure C-36: Covington City STP Effluent Flow Values

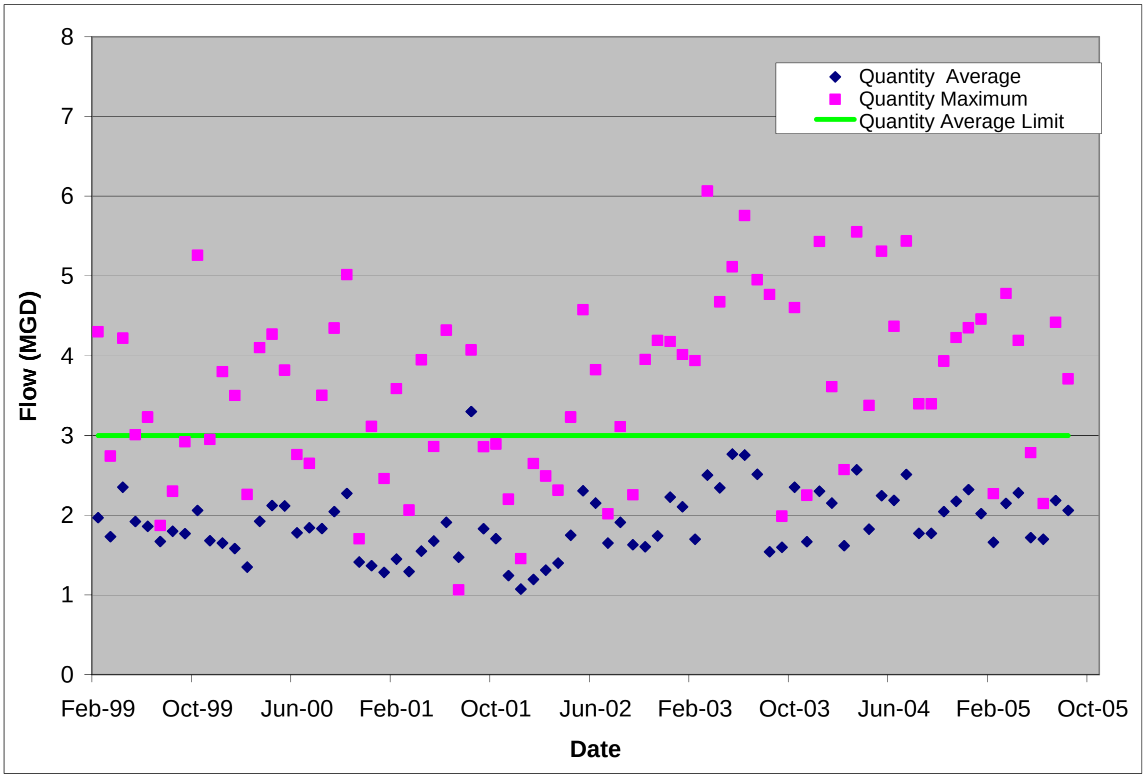


Figure C-37: Covington City STP Effluent pH Values

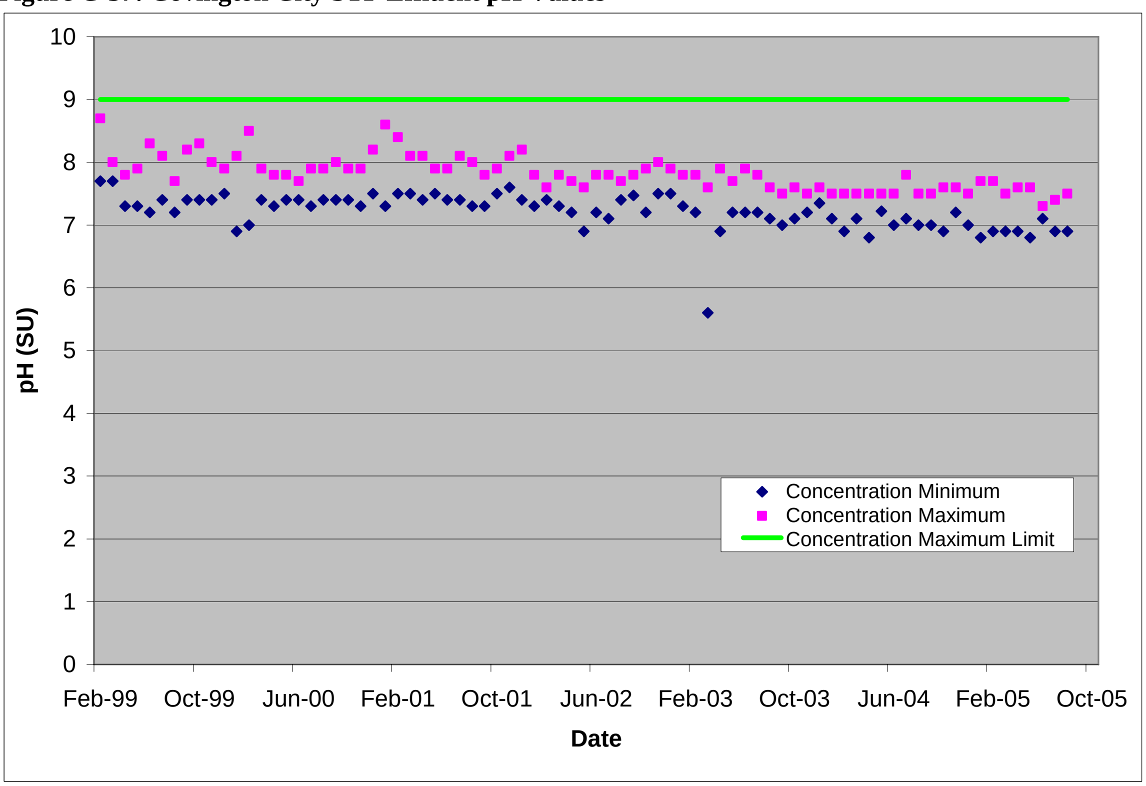


Figure C-38: Covington City STP Effluent TSS Concentrations

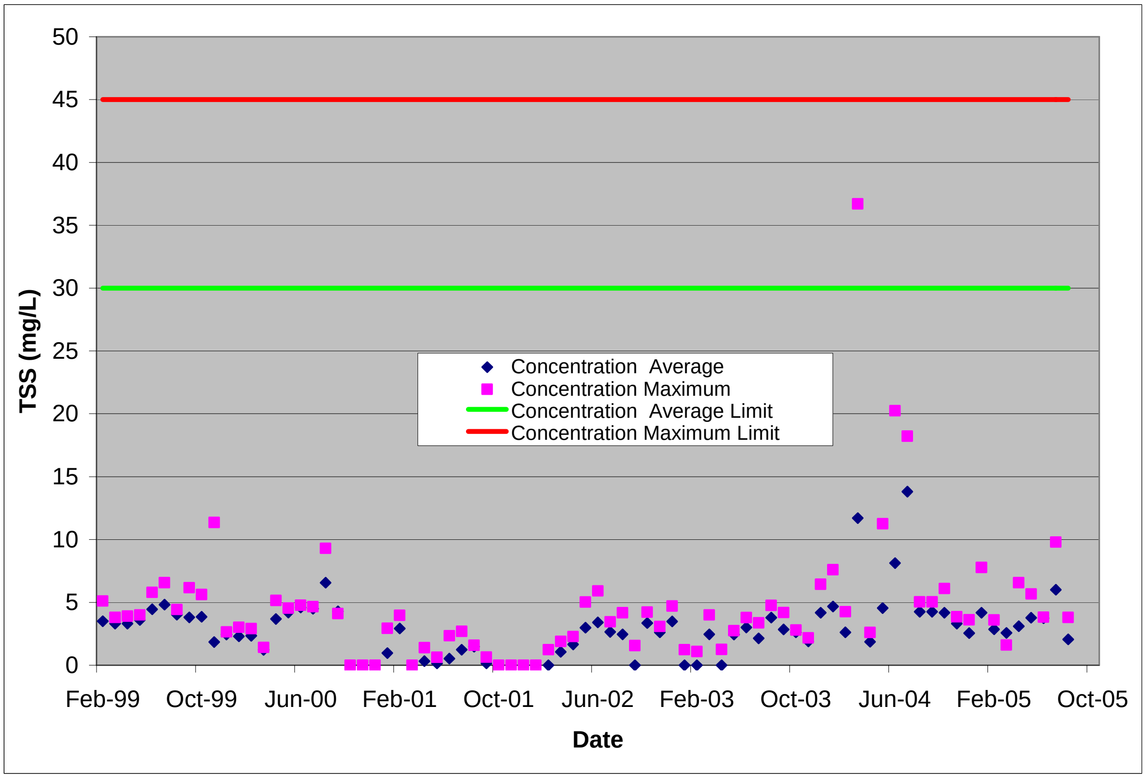


Figure C-39: Covington City STP Effluent TSS Quantities

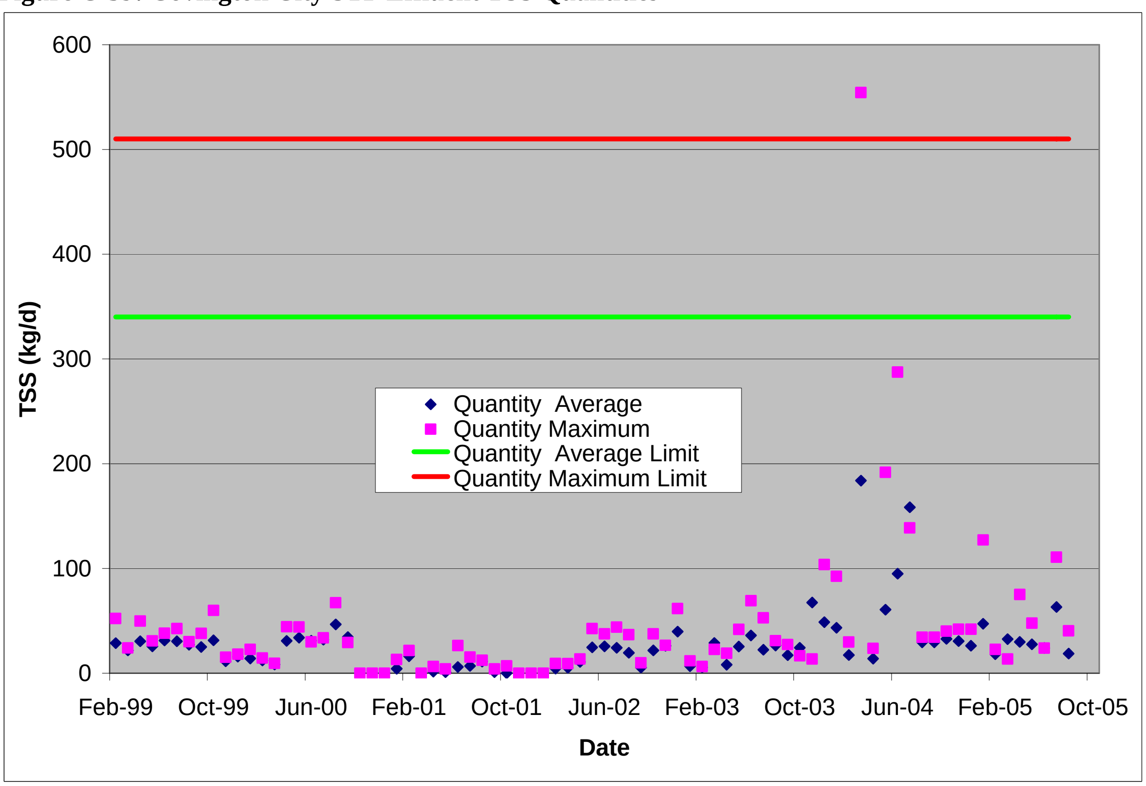


Figure C-40: Covington City STP Fecal Coliform Concentrations

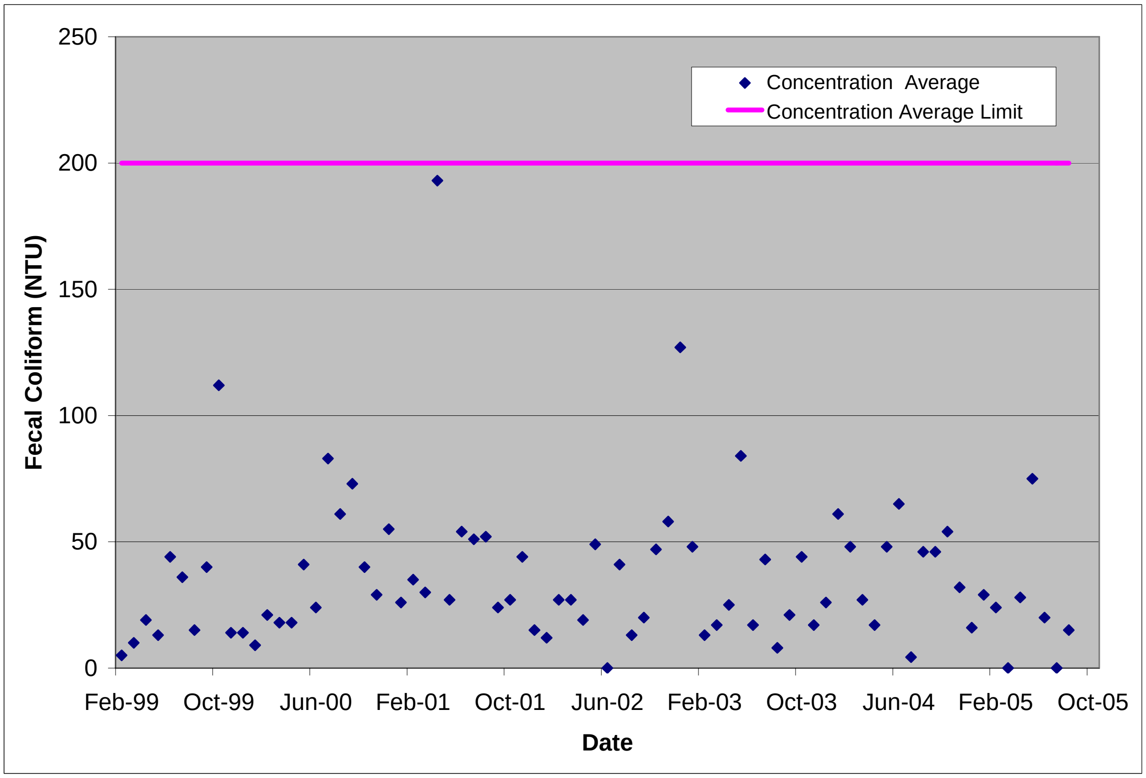


Figure C-41: Covington City STP Effluent BOD5 Concentrations

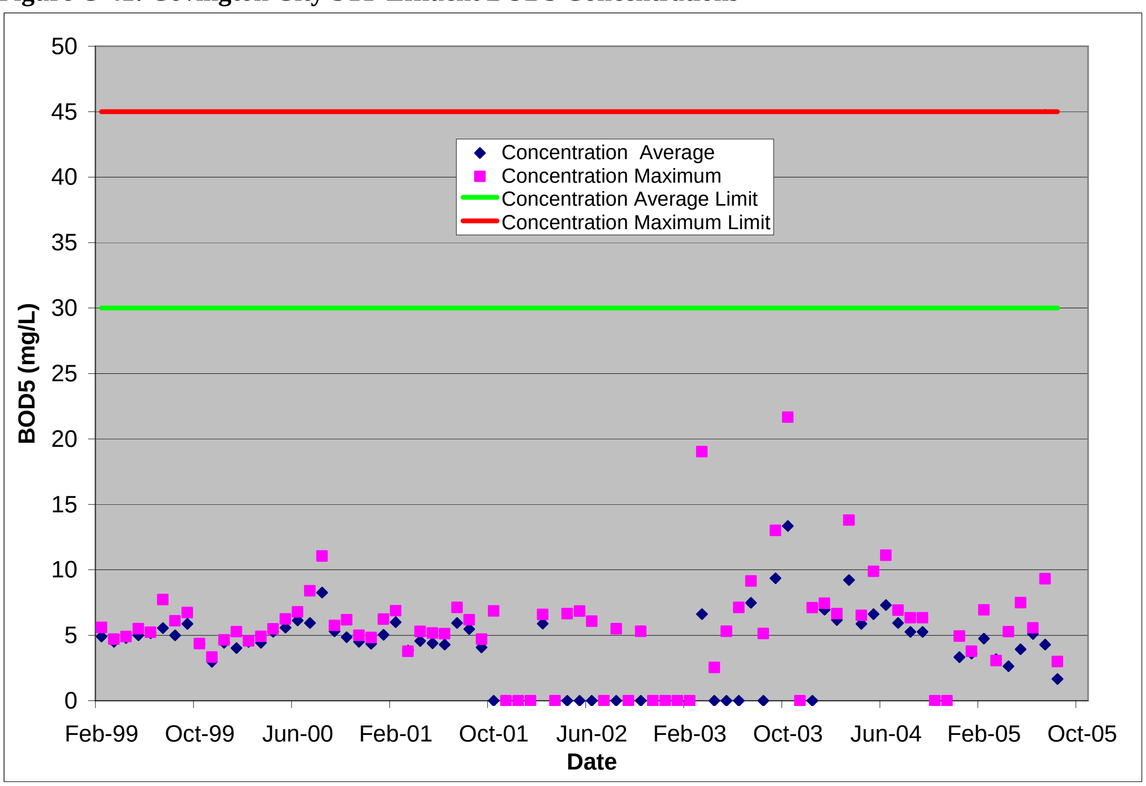


Figure C-42: Covington City STP Effluent BOD5 Quantities

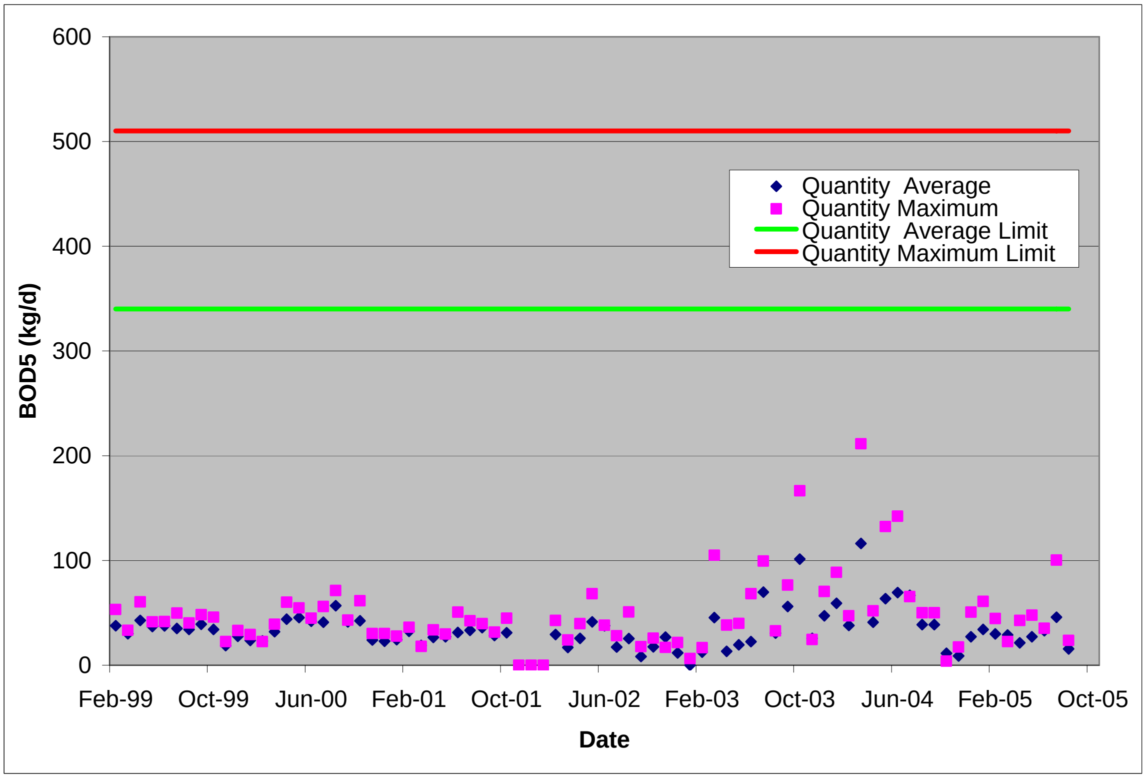


Figure C-43: Covington City STP Effluent Total Nitrogen as N Concentrations

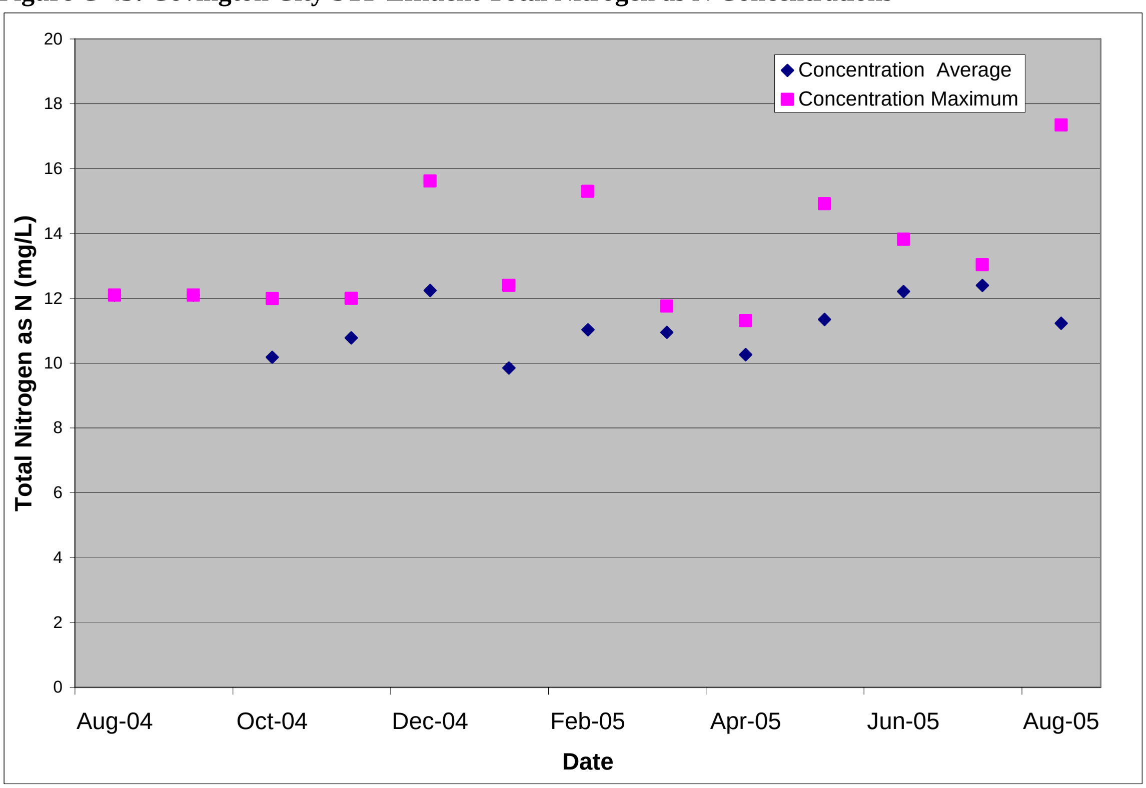


Figure C-44: Covington City STP Effluent Total Nitrogen as N Quantities

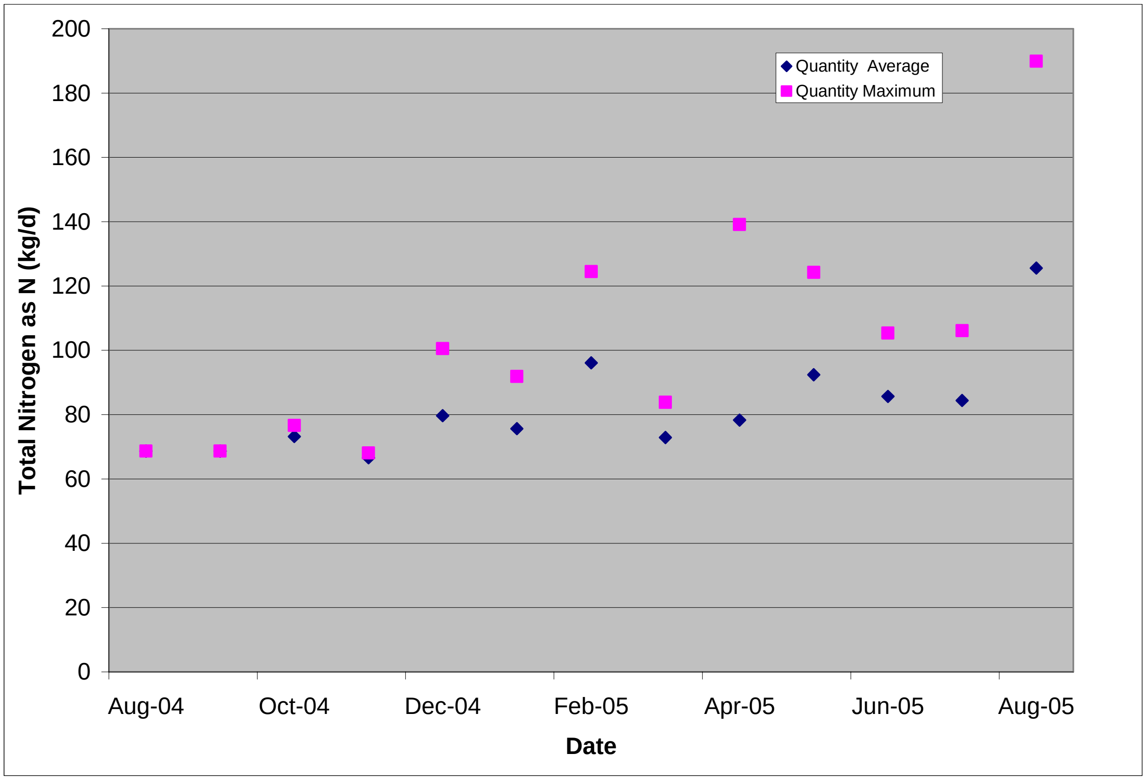


Figure C-45: Covington City STP Effluent Total Phosphorous as P Concentrations

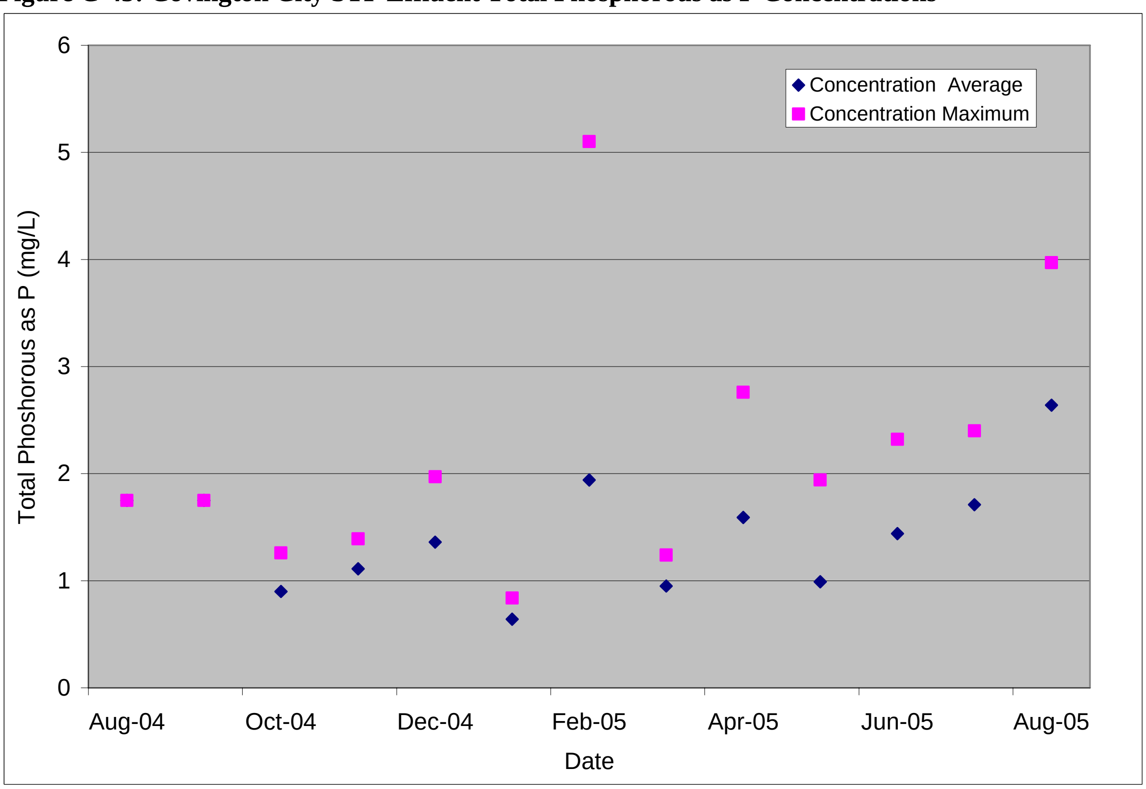


Figure C-46: Covington City STP Effluent Total Phosphorous as P Quantities

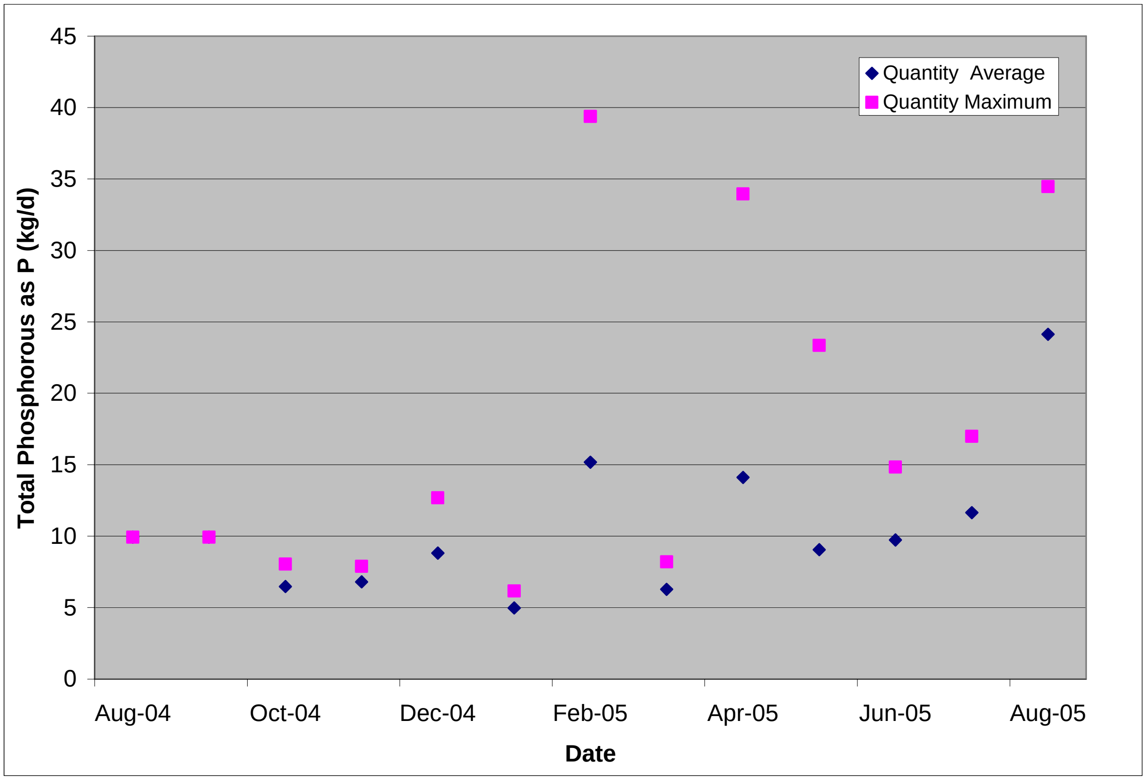


Figure C-47: CSX Transportation Effluent Flow Values

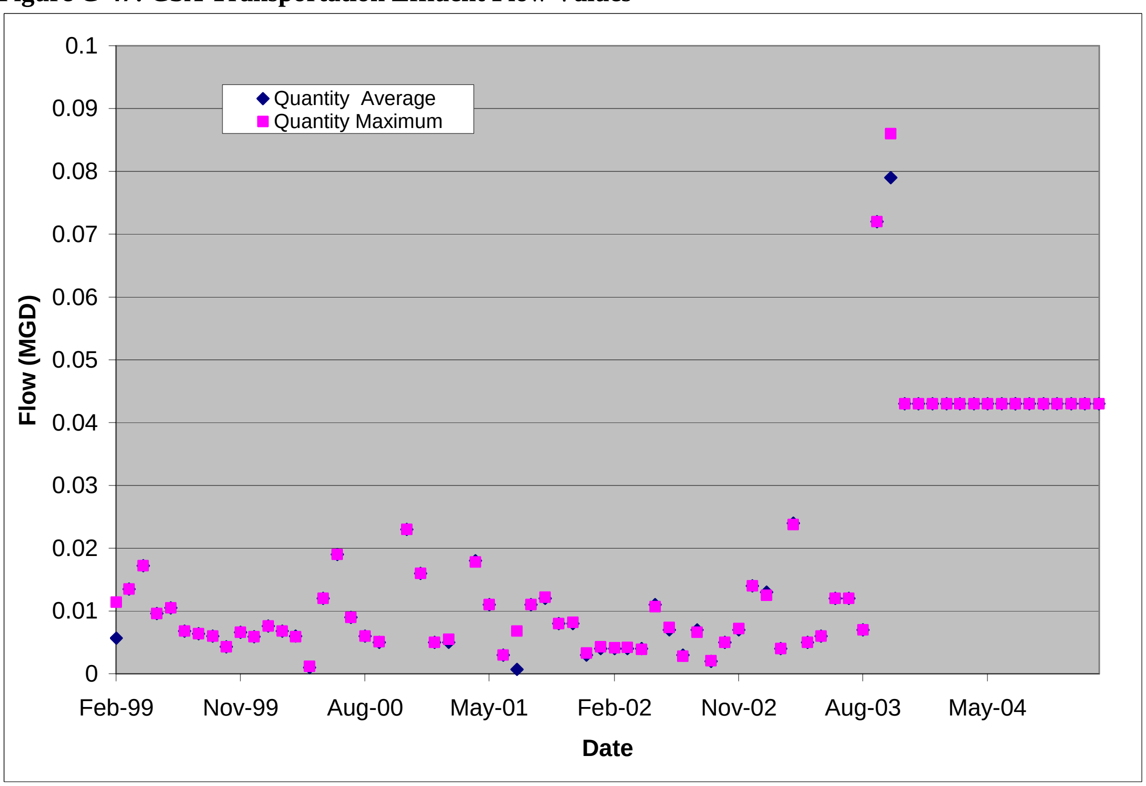


Figure C-48: CSX Transportation Effluent pH Values

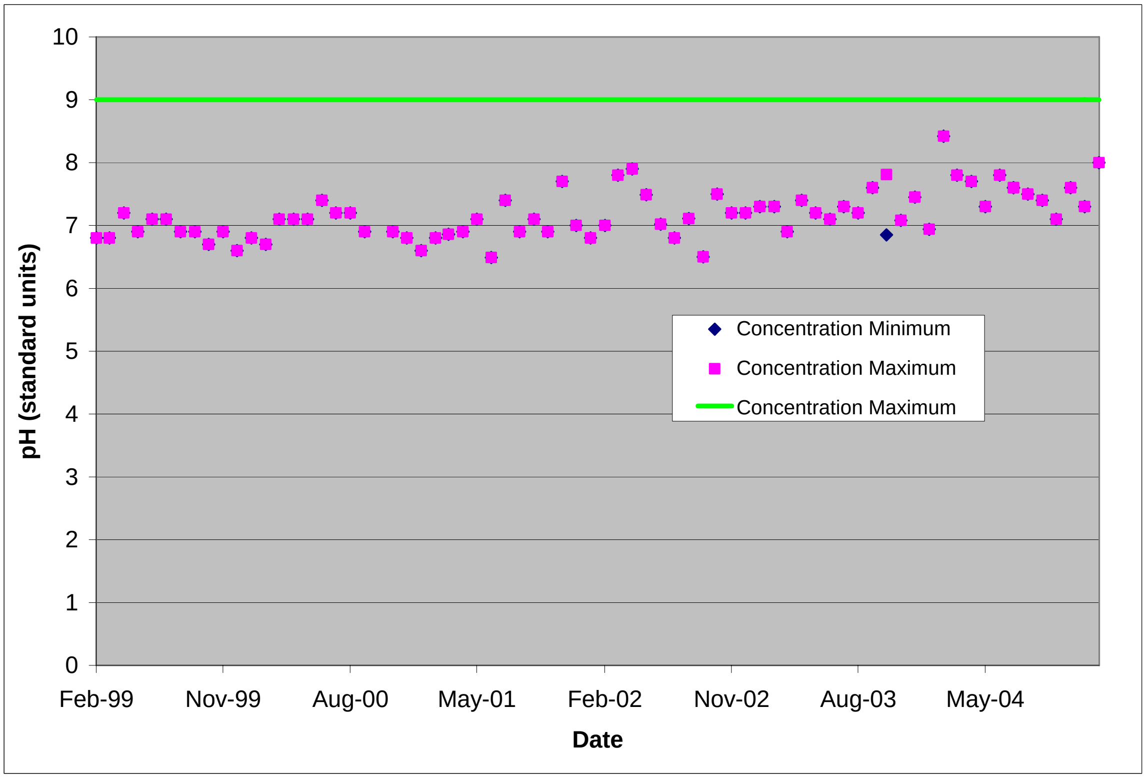


Figure C-49: CSX Transportation Effluent TSS Concentrations

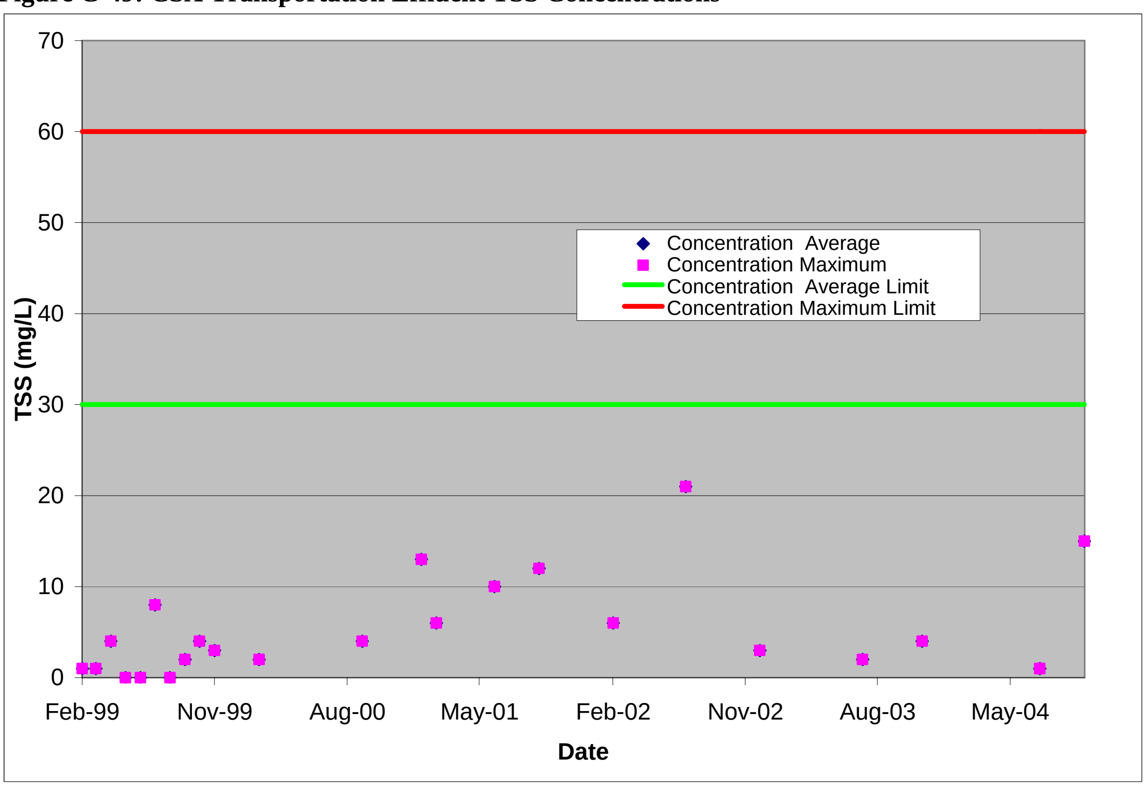


Figure C-50: CSX Transportation Effluent Acute Toxicity Values

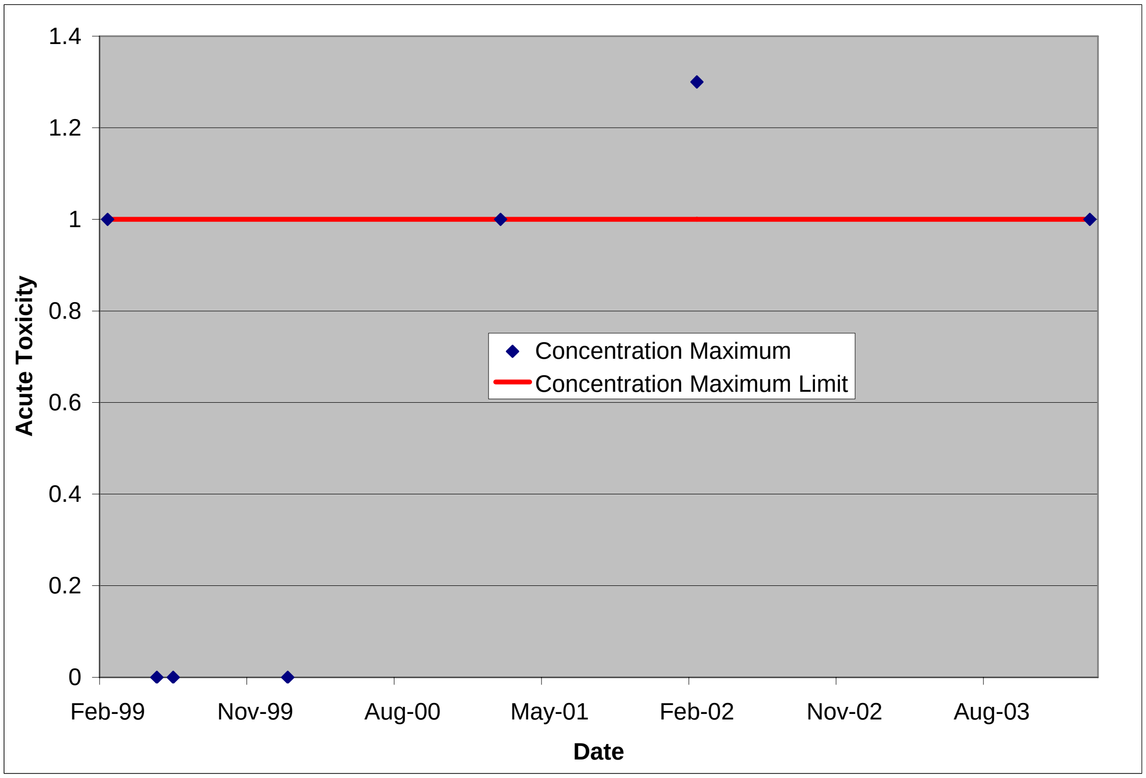


Figure C-51: CSX Transportation Effluent Petroleum Hydrocarbon Concentrations

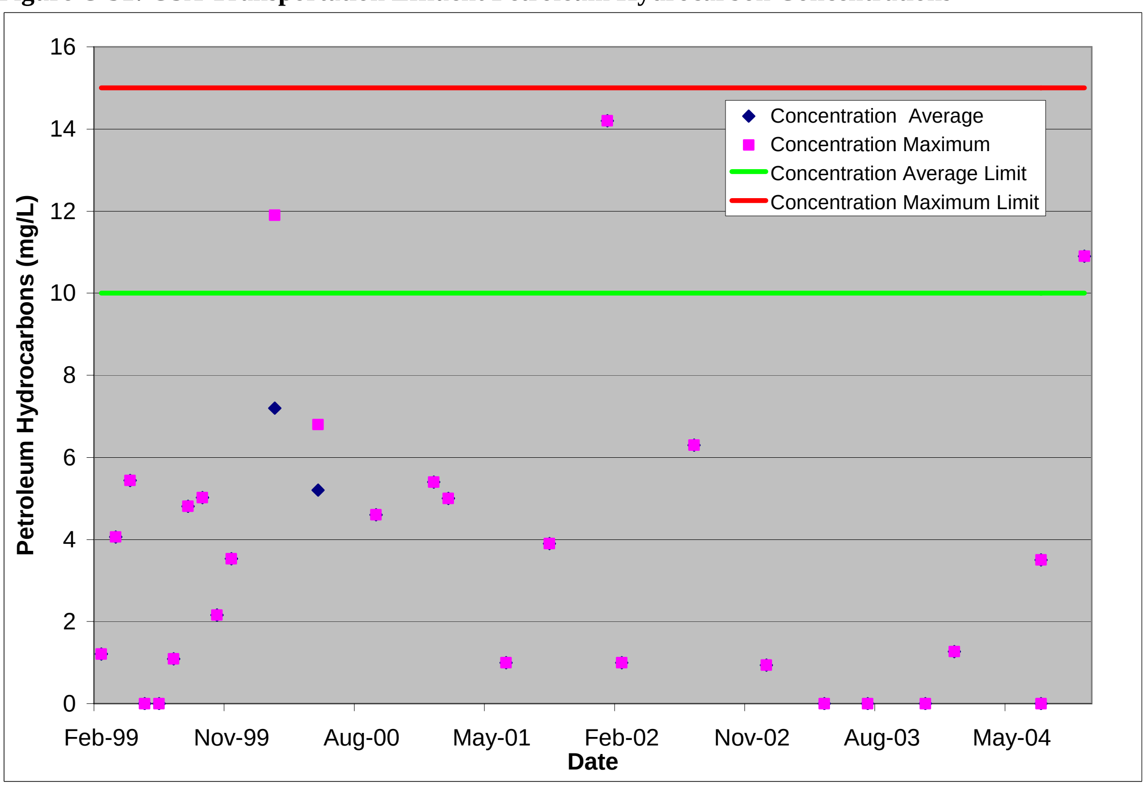


Figure C-52: CSX Transportation Effluent Oil and Grease Concentrations

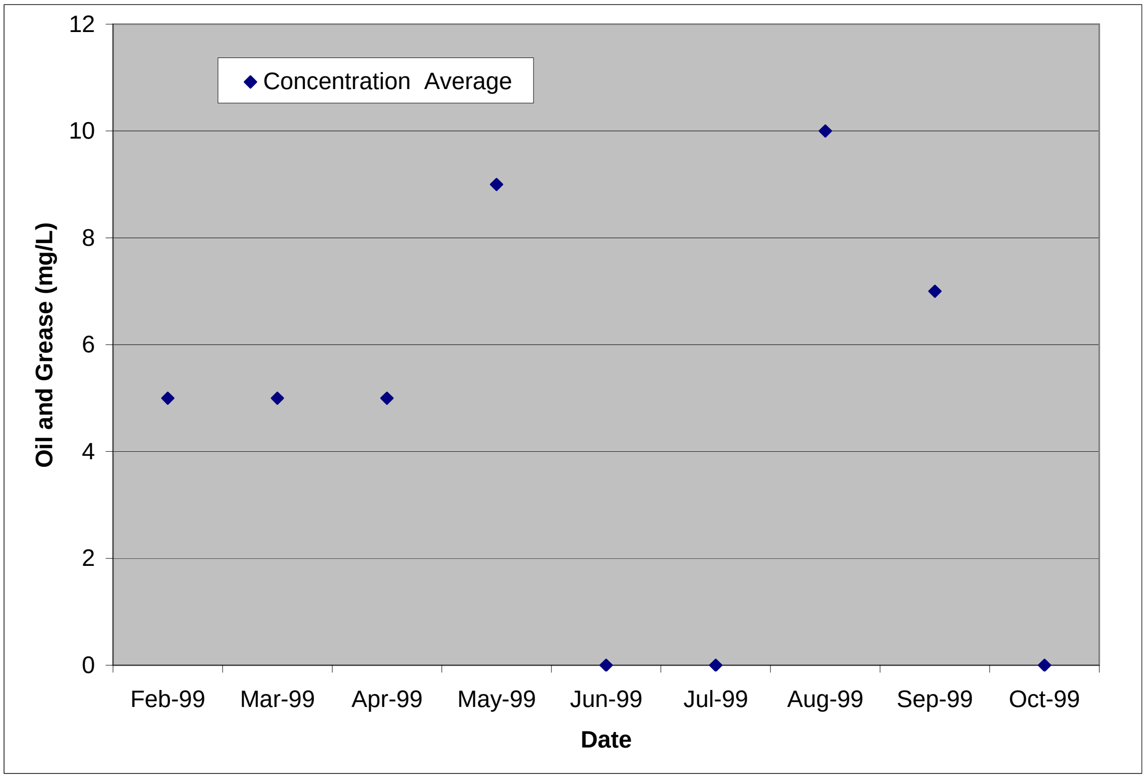


Figure C-53: DGIF Paint Bank Fish Cultural Station Effluent Flow Values from Outfall 1

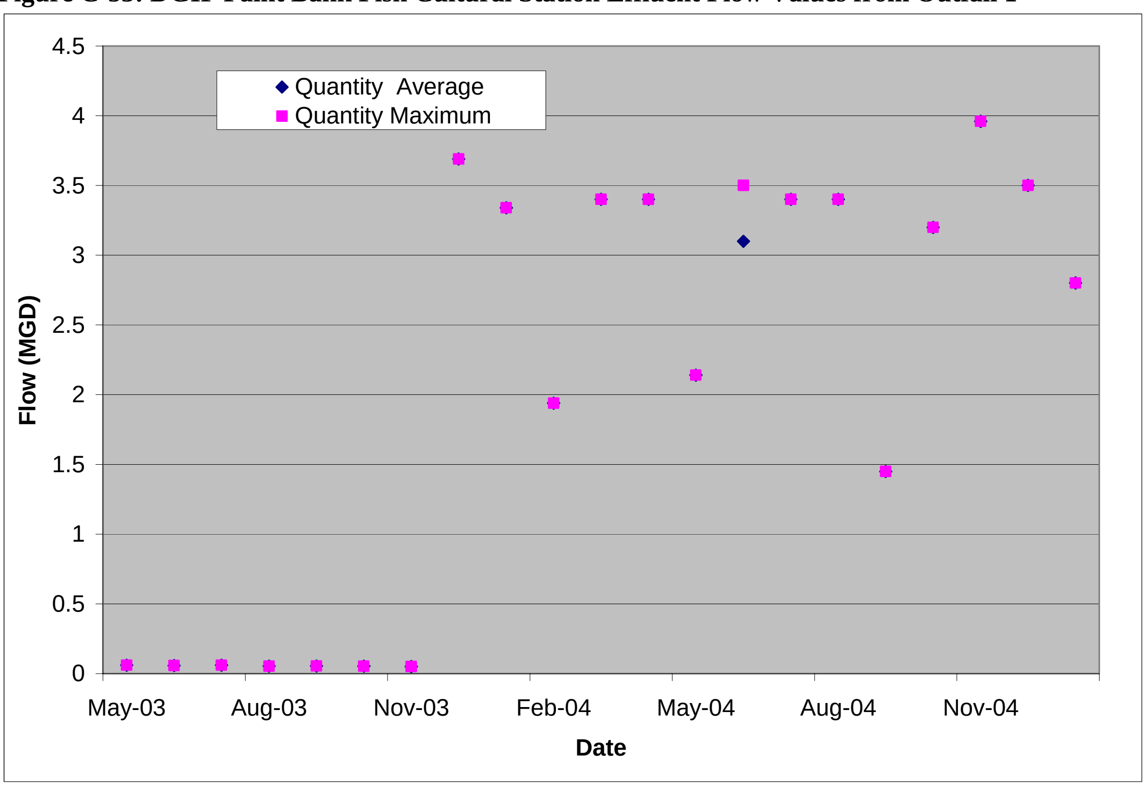


Figure C-54: DGIF Paint Bank Fish Cultural Station Effluent TSS Concentrations from Outfall 1

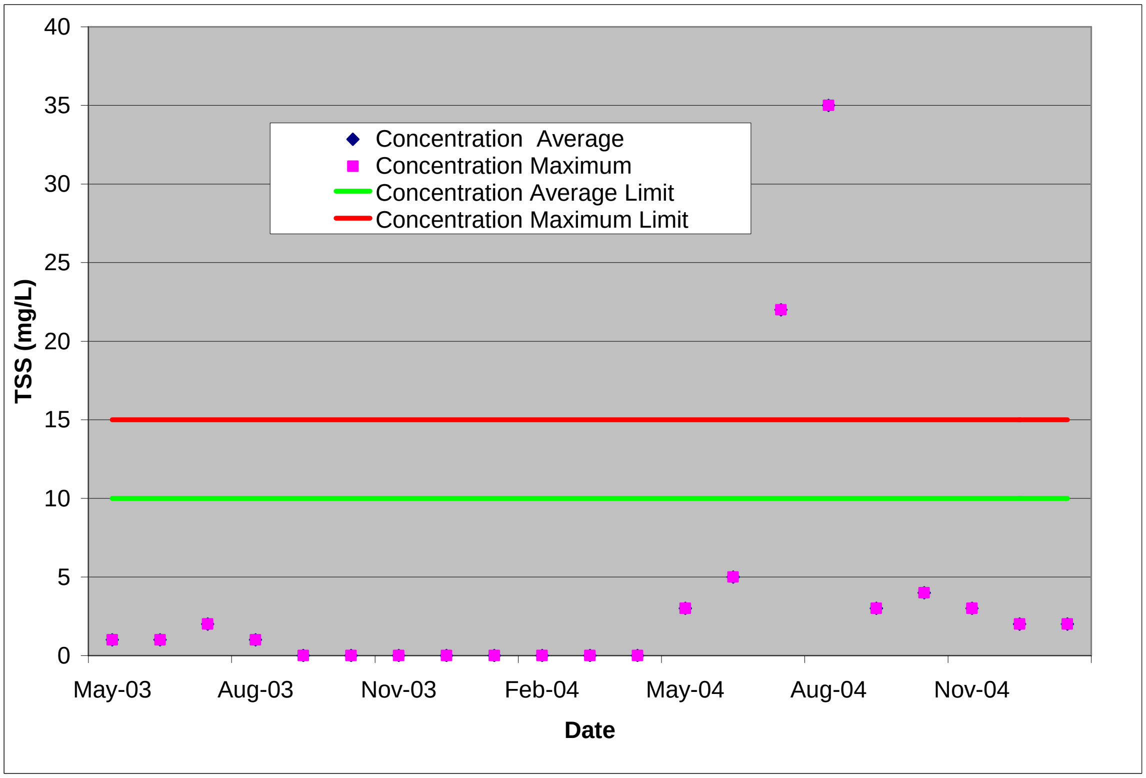


Figure C-55: DGIF Paint Bank Fish Cultural Station Effluent Settable Solids Concentrations from Outfall 1

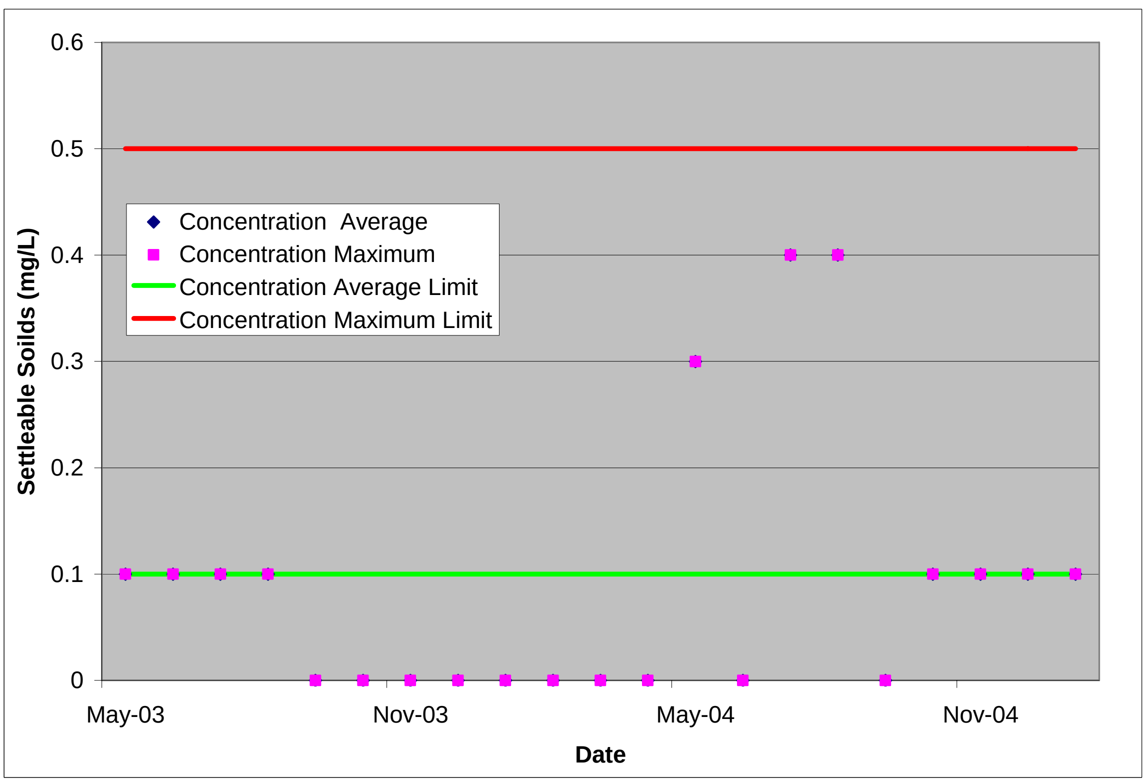


Figure C-56: DGIF Paint Bank Fish Cultural Station Effluent Flow Values from Outfall 3

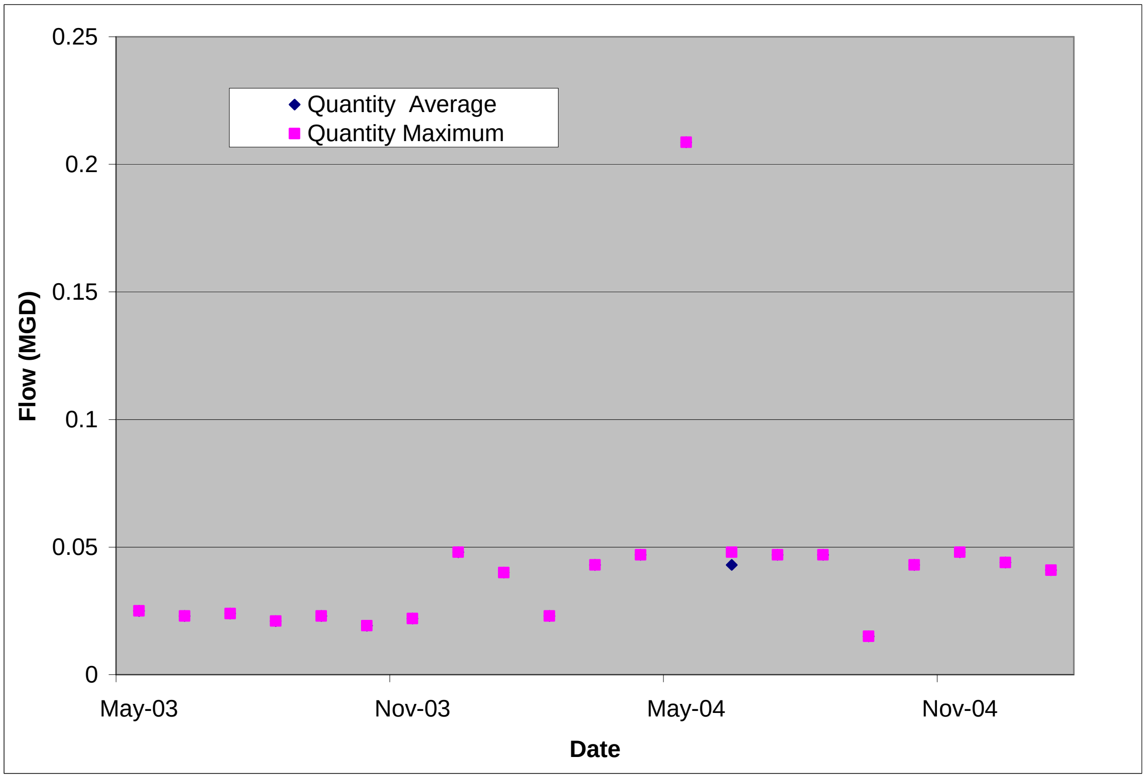


Figure C-57: DGIF Paint Bank Fish Cultural Station Effluent TSS Concentrations from Outfall 3

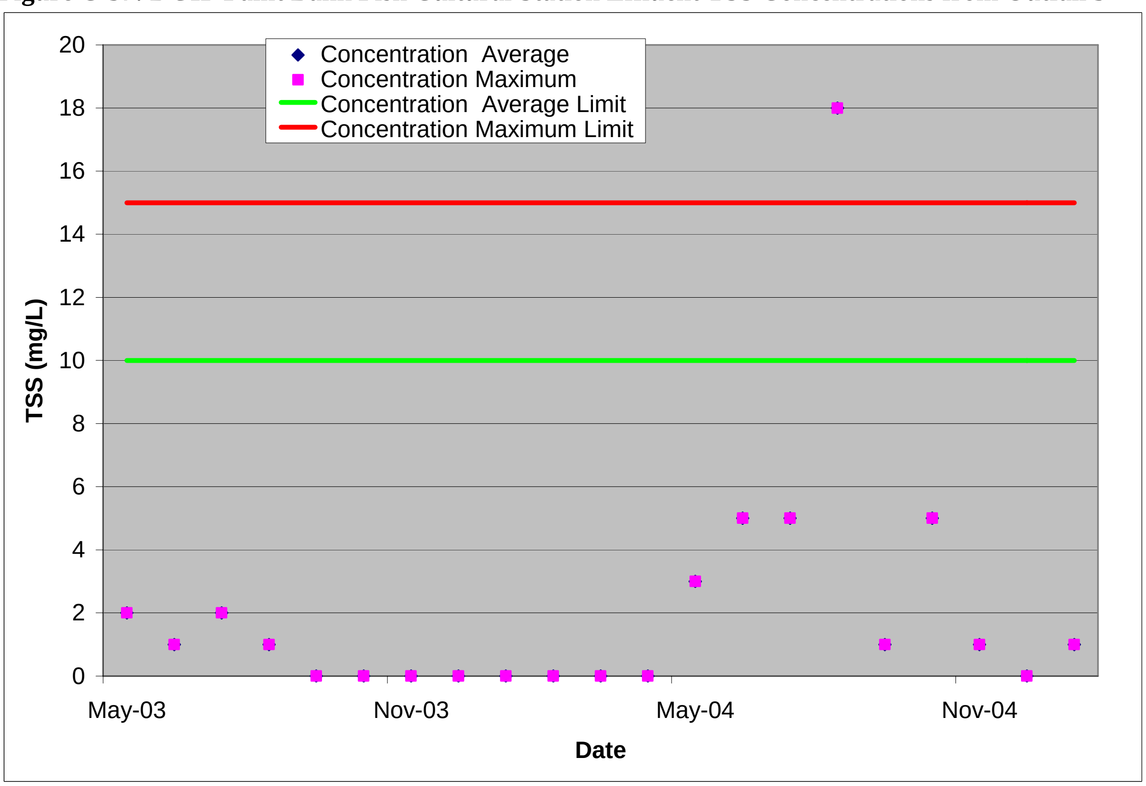


Figure C-58: DGIF Paint Bank Fish Cultural Station Settleable Solids Concentrations from Outfall 3

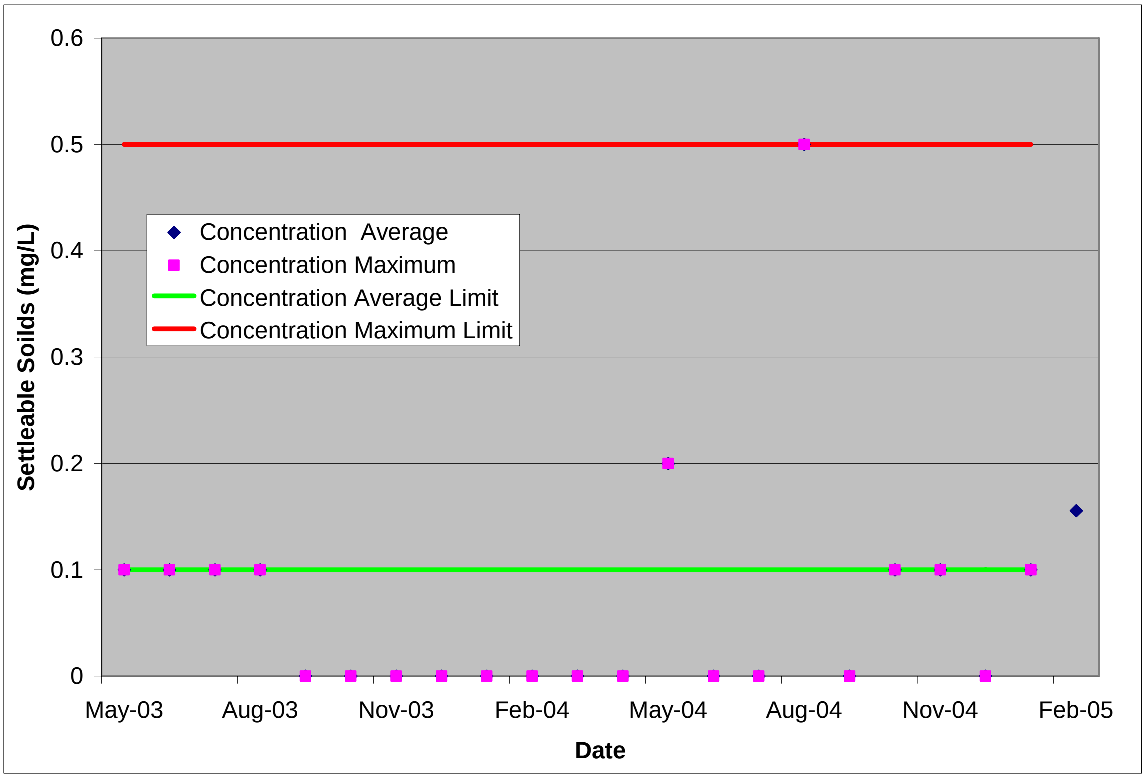


Figure C-59: DGIF Paint Bank Fish Cultural Station Flow Values from Outfall 4

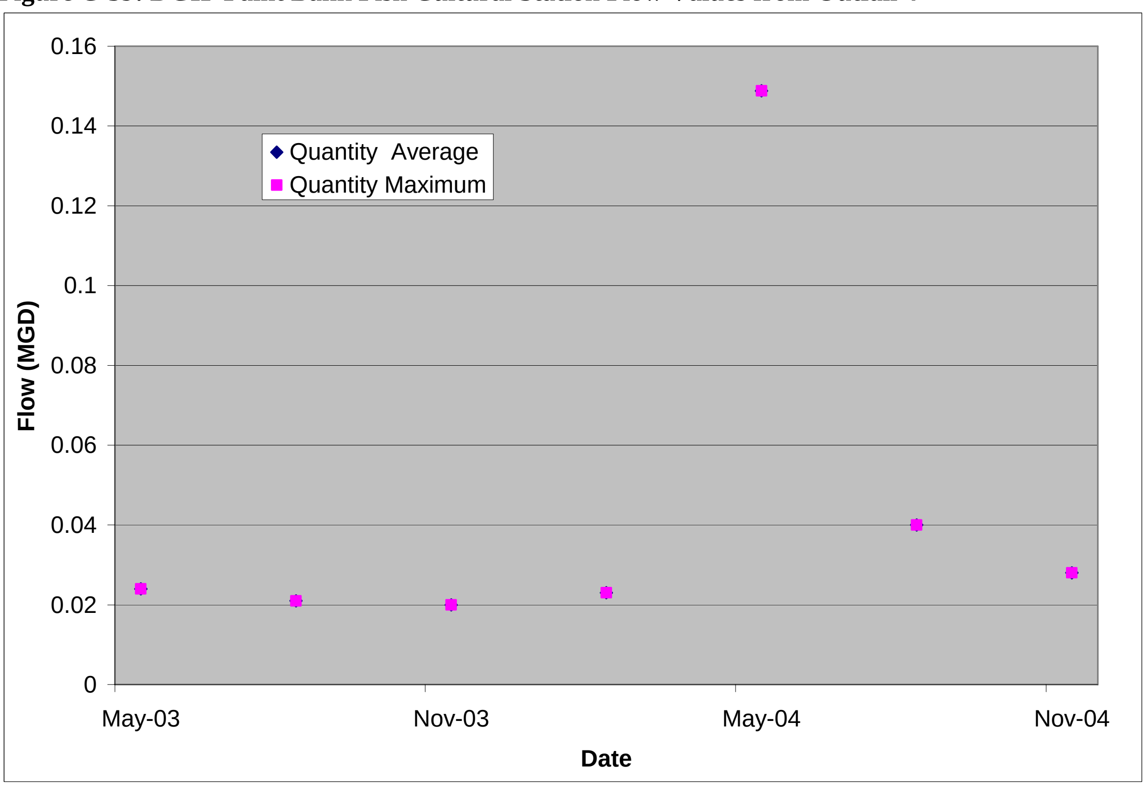


Figure C-60: DGIF Paint Bank Fish Cultural Station Effluent Settable Solids Concentrations from Outfall 4

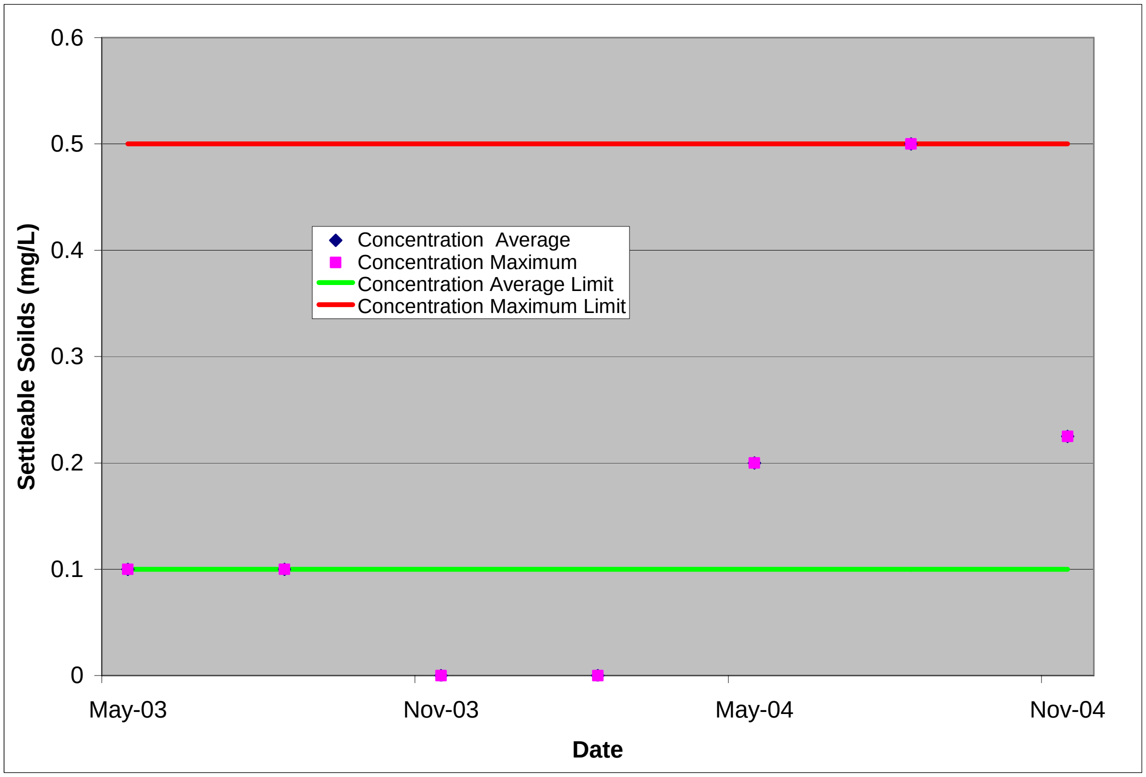


Figure C-61: DGIF Paint Bank Fish Cultural Station Effluent TSS Concentrations from Outfall 4

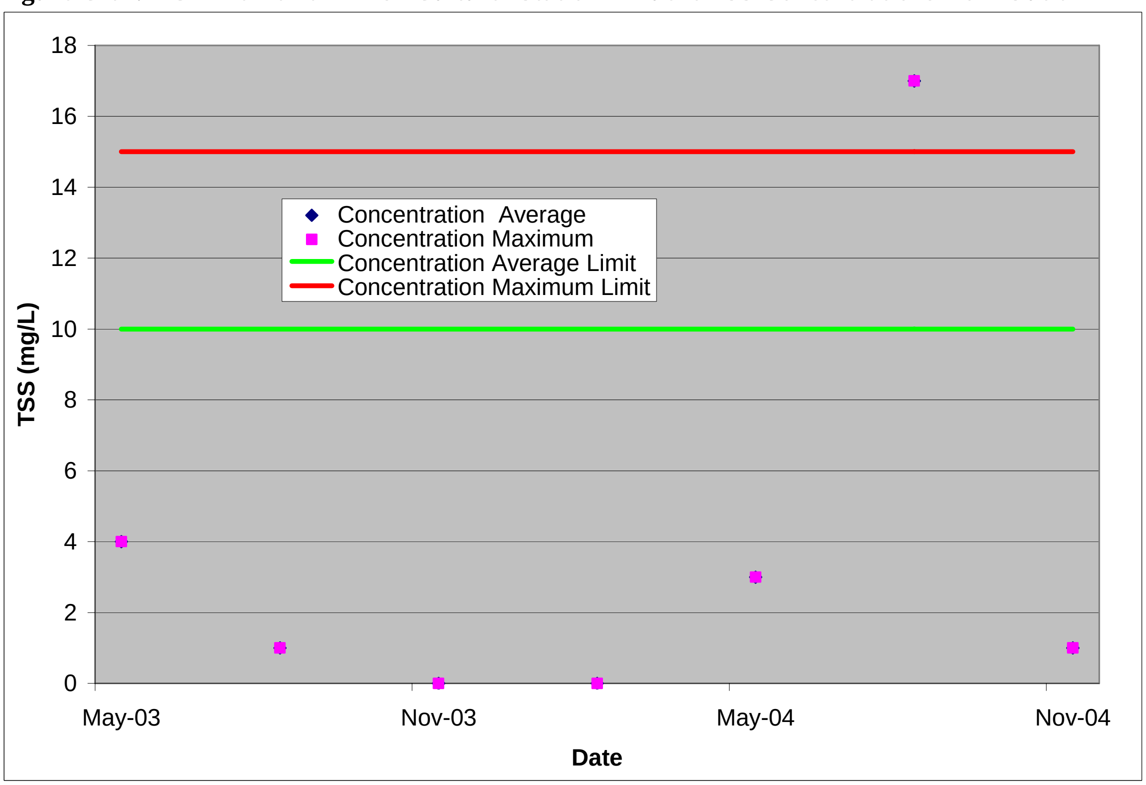


Figure C-62: DGIF Paint Bank Fish Cultural Station Flow Values from Outfall 5

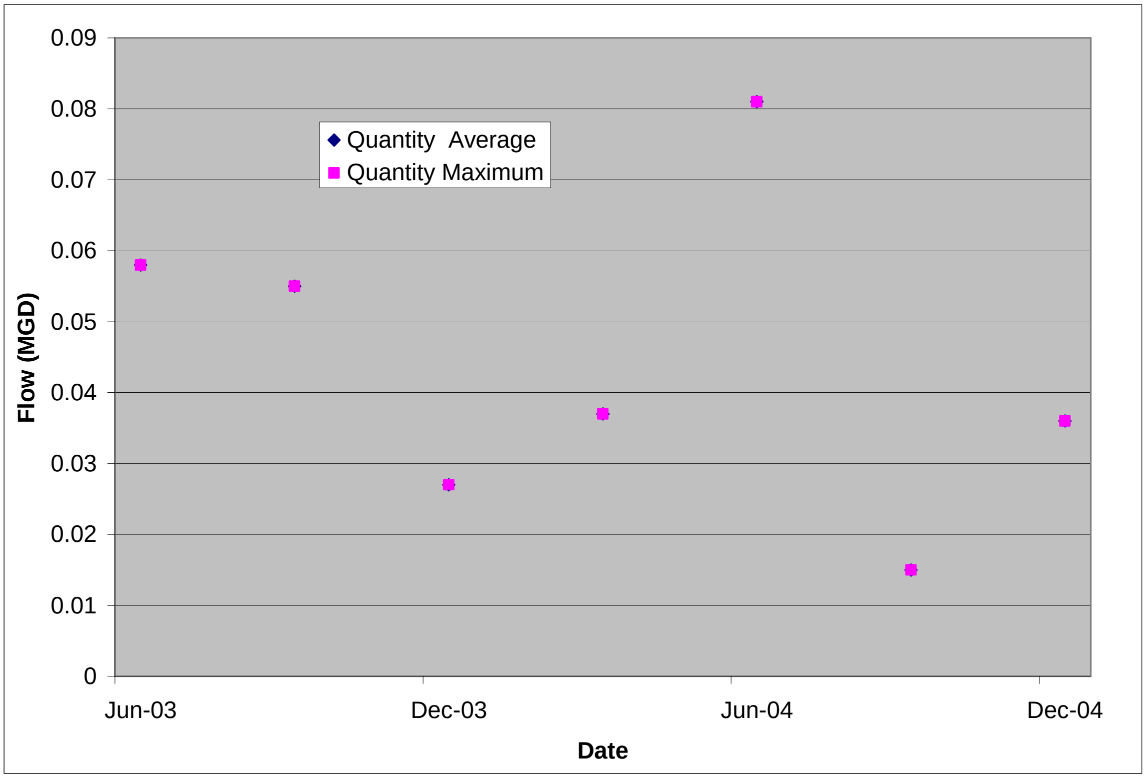


Figure C-63: DGIF Paint Bank Fish Cultural Station Effluent TSS Concentrations from Outfall 5

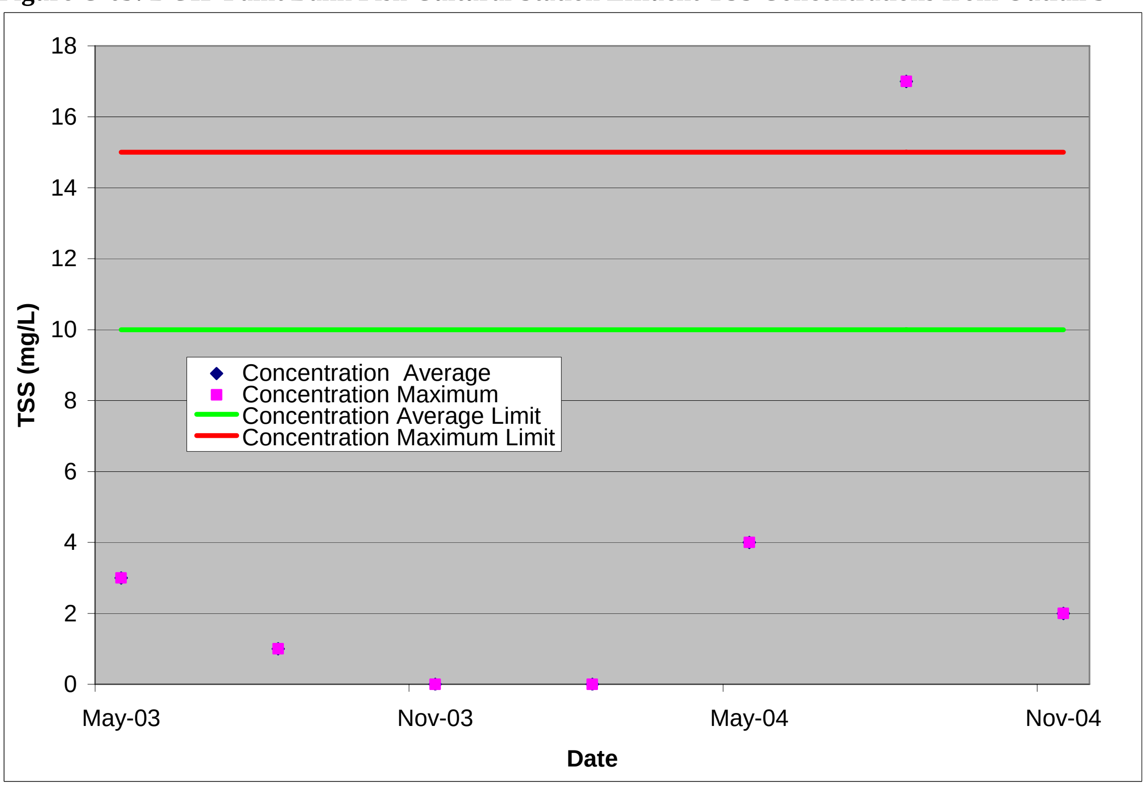


Figure C-64: DGIF Paint Bank Fish Cultural Station Effluent Settable Solids Concentrations from Outfall 5

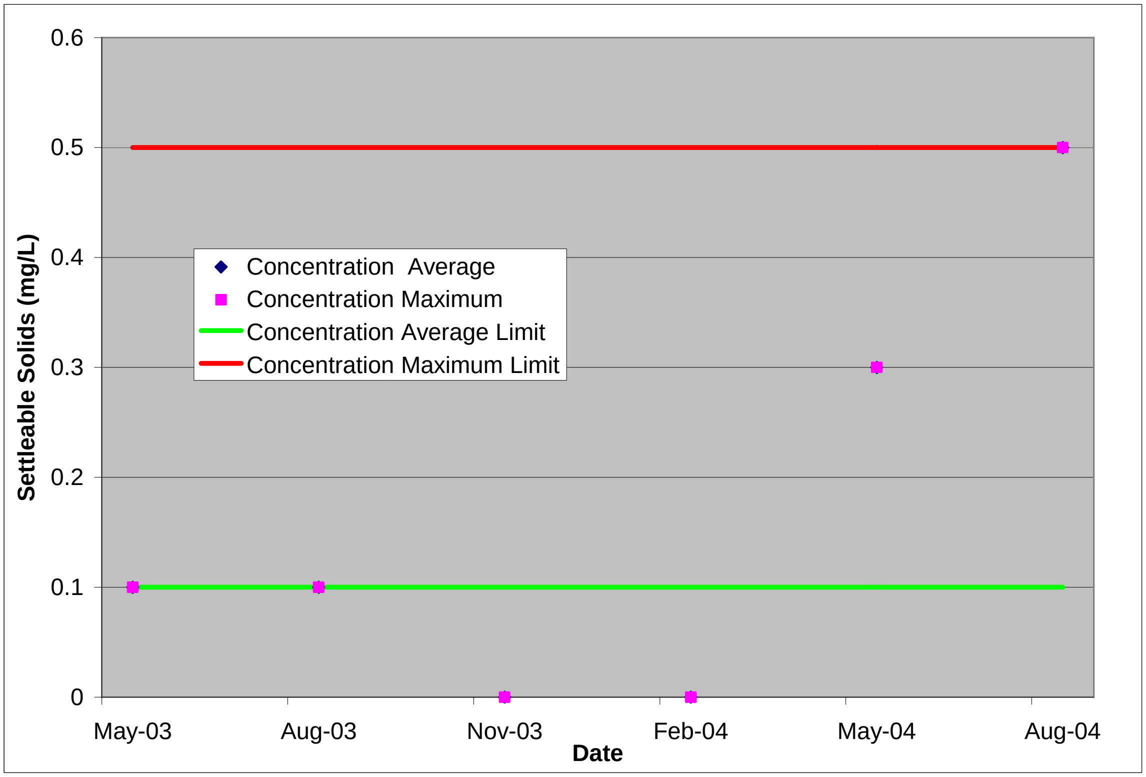


Figure C-65: DGIF Paint Bank Fish Cultural Station Effluent Flow Values from Outfall 6

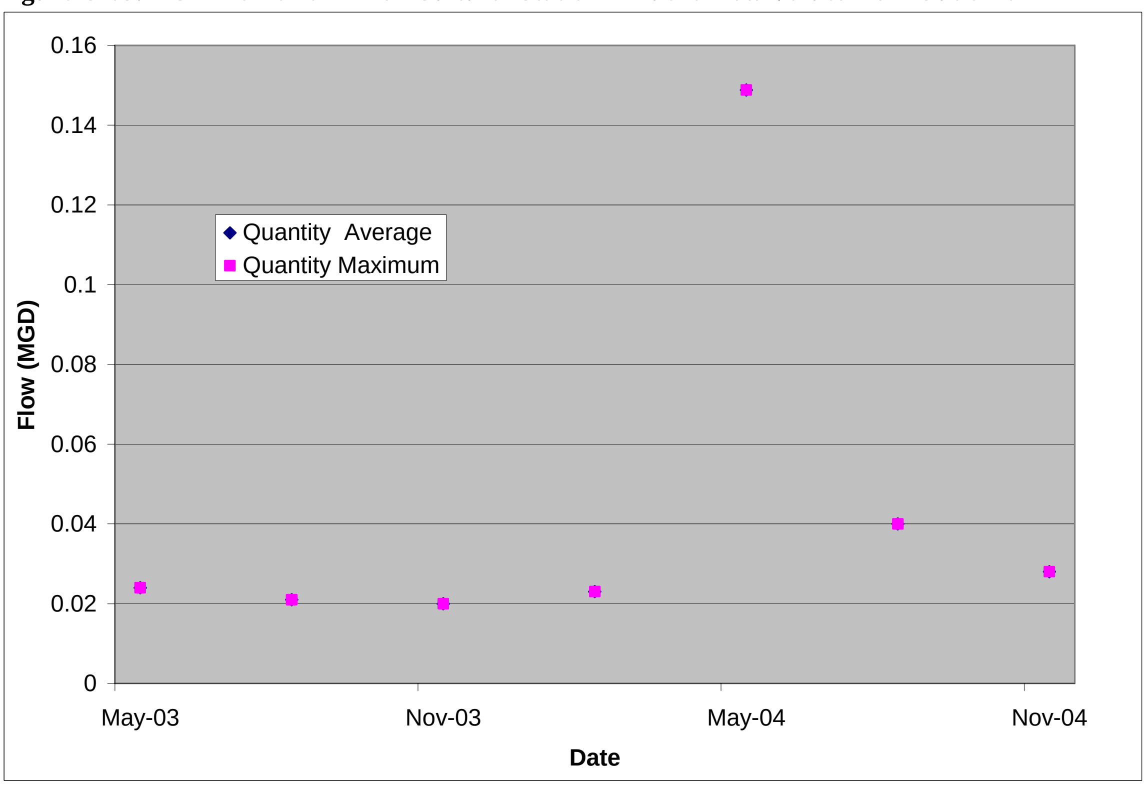


Figure C-66: DGIF Paint Bank Fish Cultural Station Effluent TSS Concentrations from Outfall 6

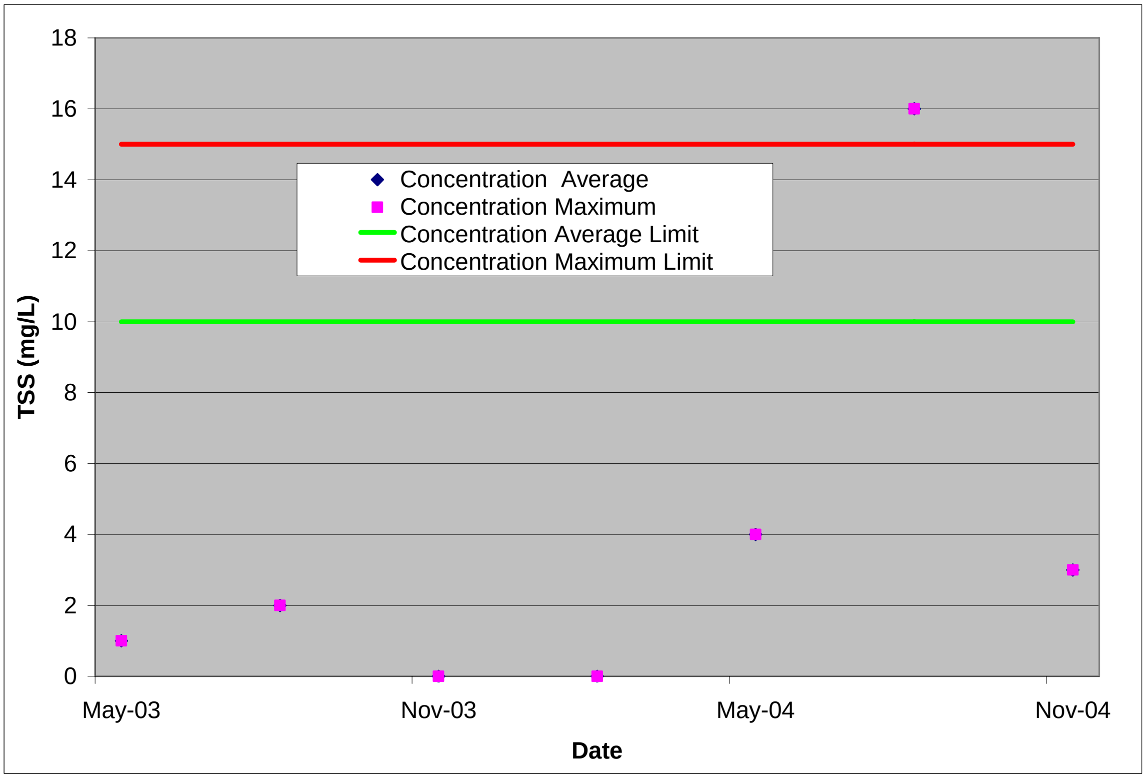


Figure C-67: DGIF Paint Bank Fish Cultural Station Effluent Settable Solids Concentrations from Outfall 6

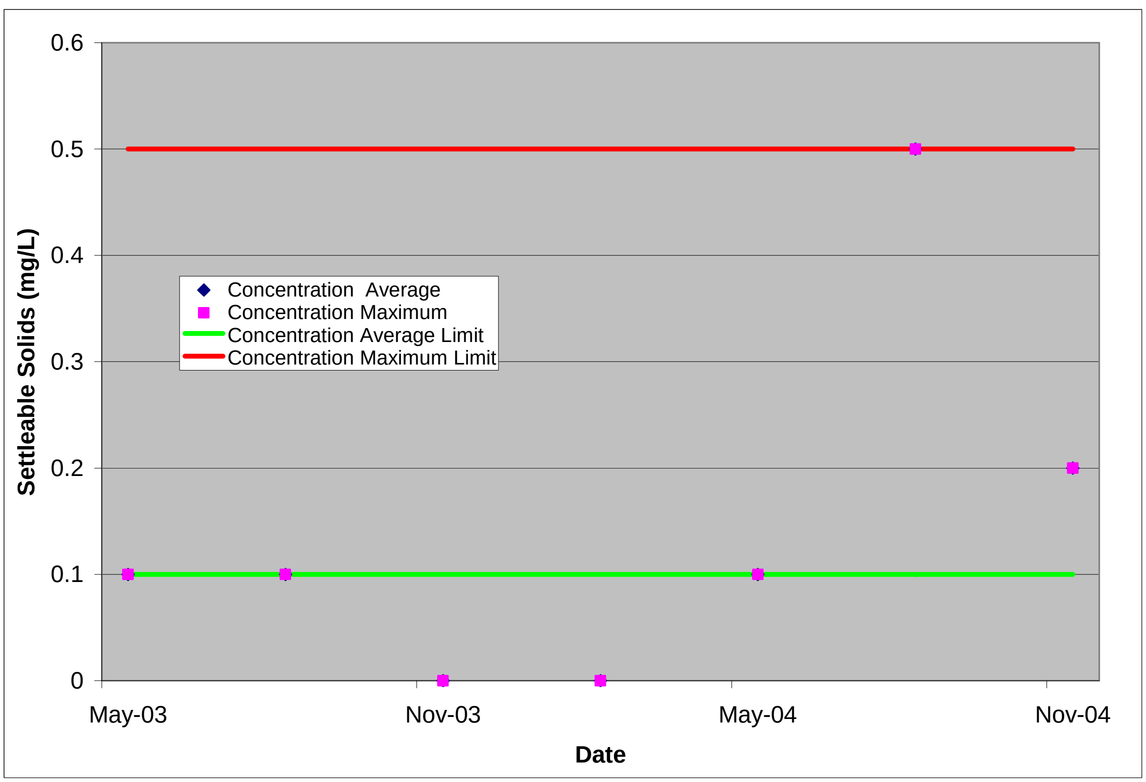


Figure C-68: DGIF Paint Bank Fish Cultural Station Effluent Flow Values from Outfall 8

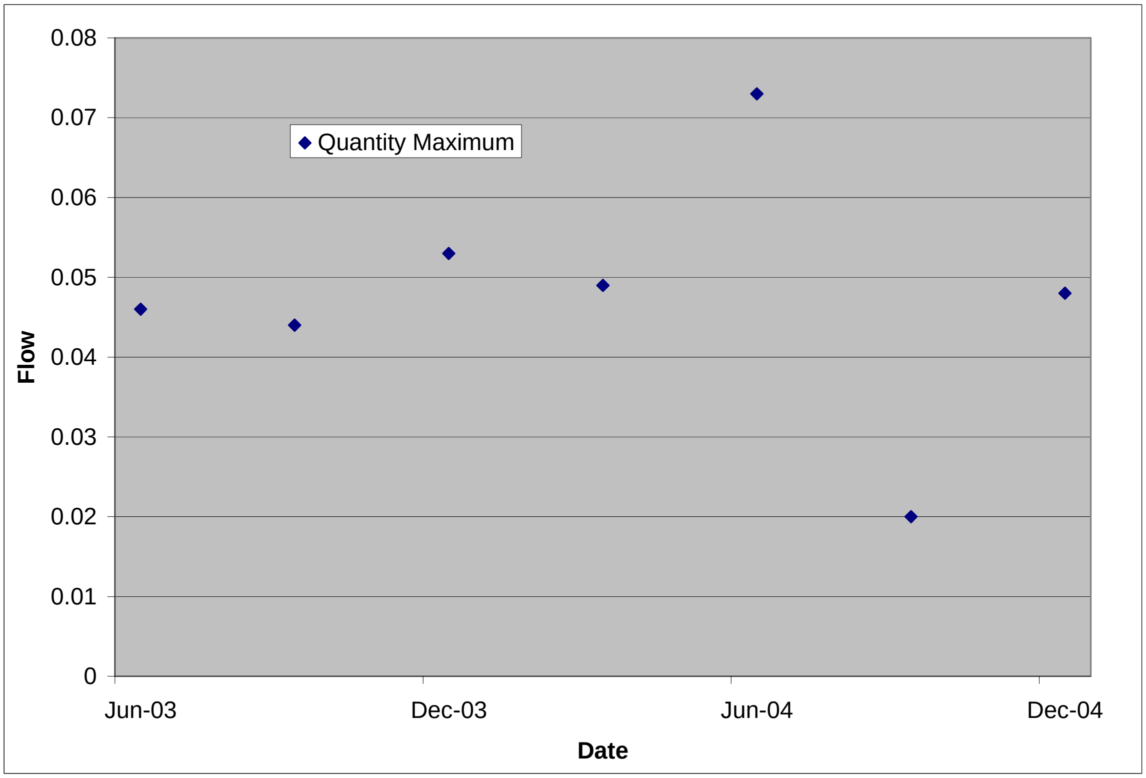


Figure C-69: DGIF Paint Bank Fish Cultural Station Effluent Total Suspended Solids Concentrations from Outfall 8

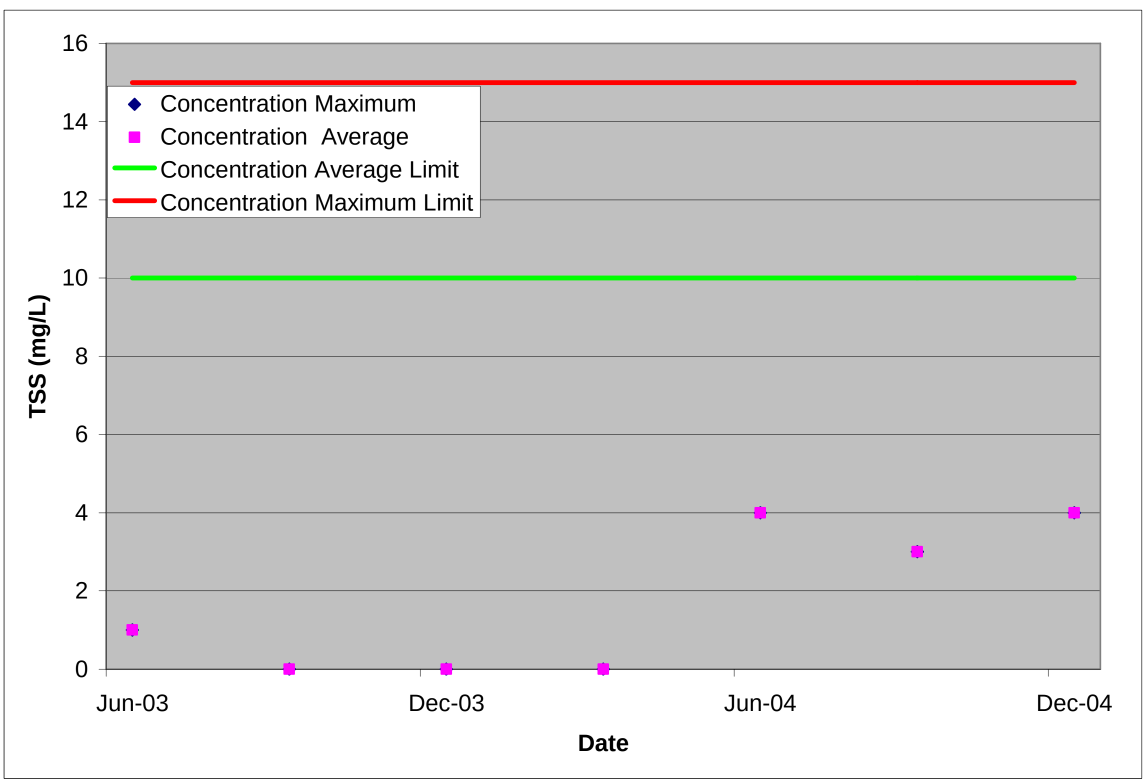


Figure C-70: DGIF Paint Bank Fish Cultural Station Effluent Ammonia Concentrations from Outfall 8

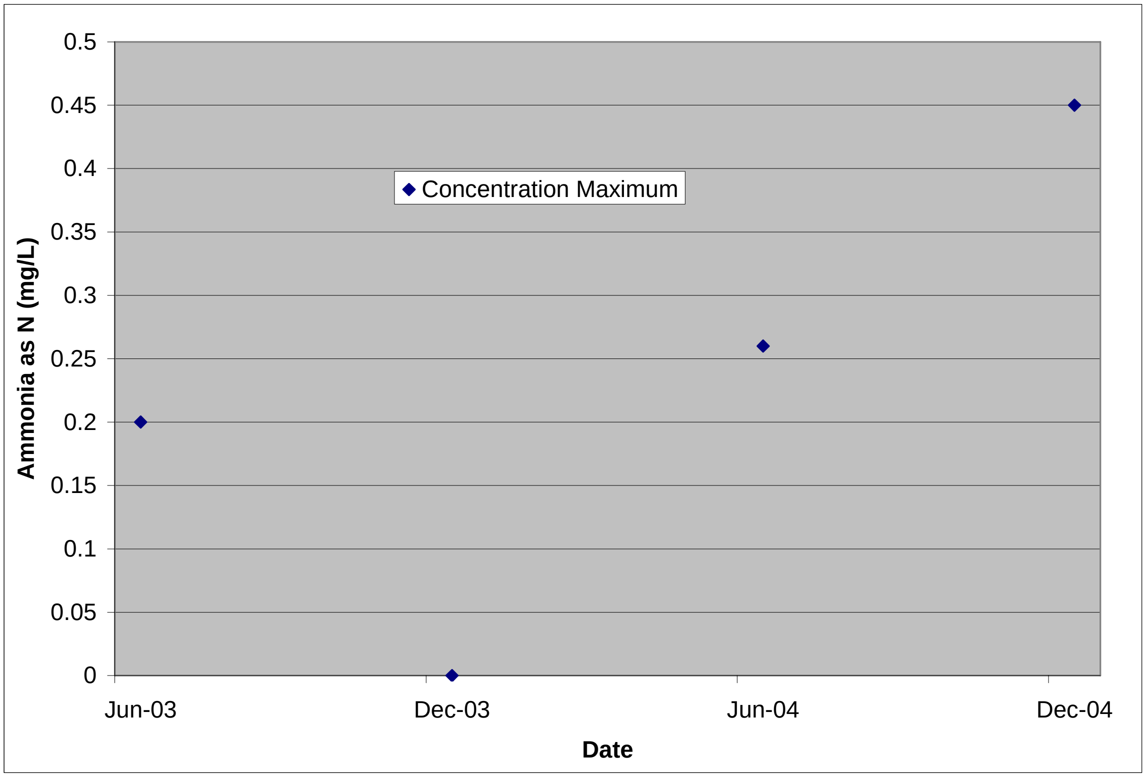


Figure C-71: DGIF Paint Bank Fish Cultural Station Effluent Flow Values from Outfall 9

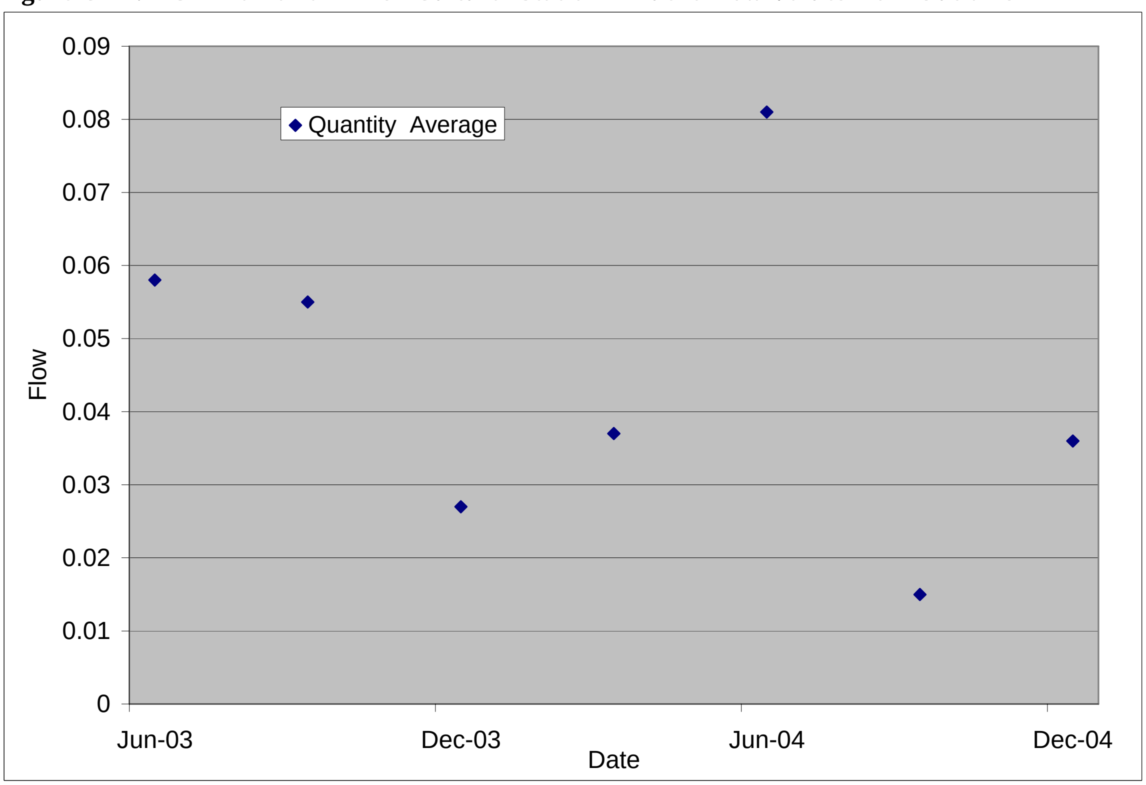


Figure C-72: DGIF Paint Bank Fish Cultural Station Effluent TSS Concentrations from Outfall 9

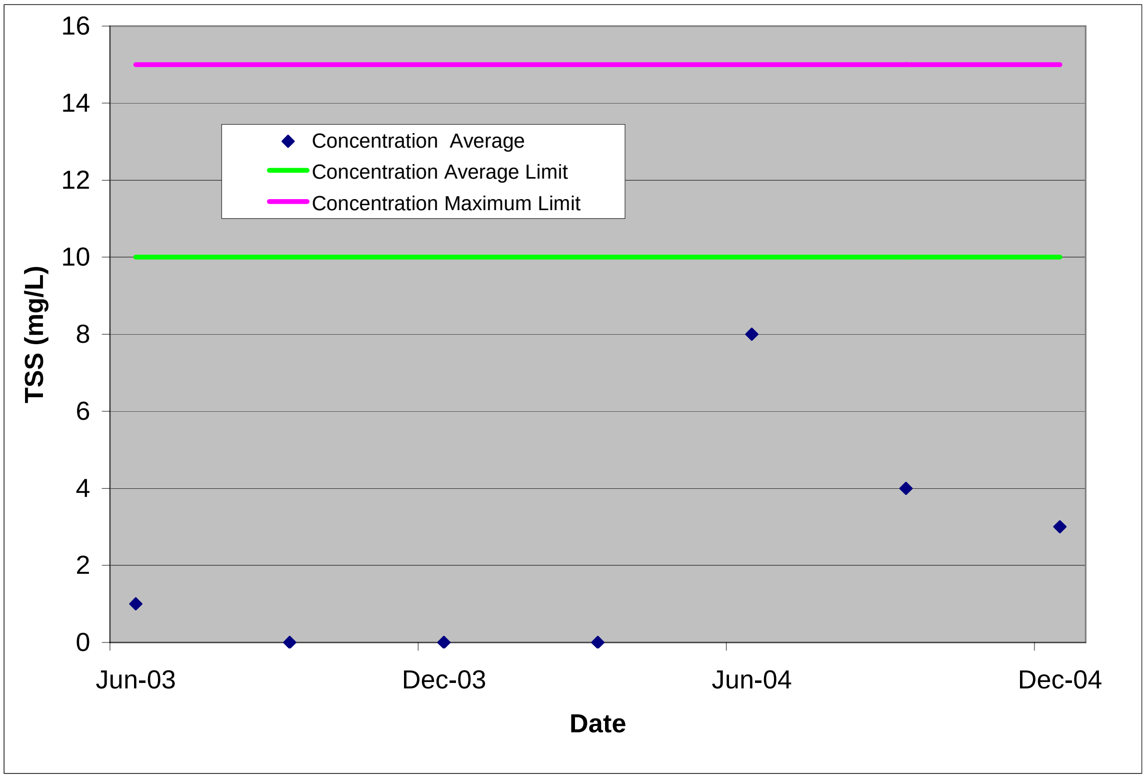


Figure C-73: DGIF Paint Bank Fish Cultural Station Settable Solids Concentrations from Outfall 9

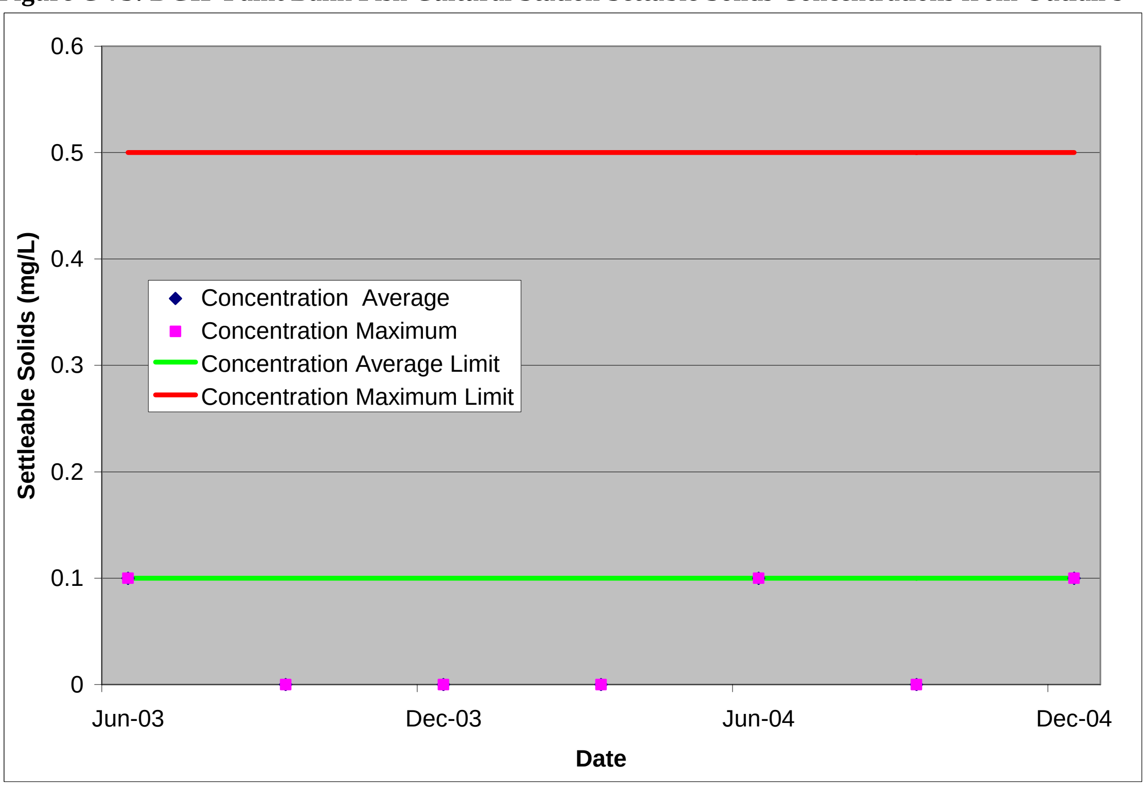


Figure C-74: Douthat Mobile Home Effluent Flow Values

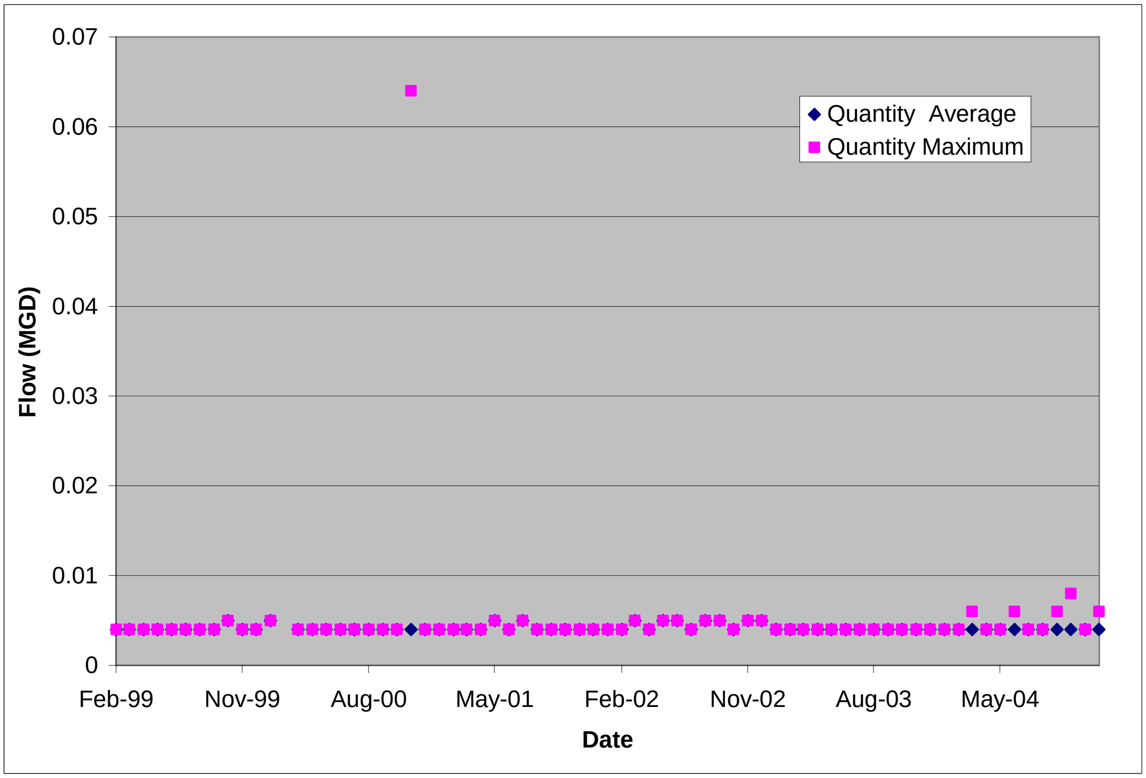


Figure C-75: Douthat Mobile Home Effluent pH Values

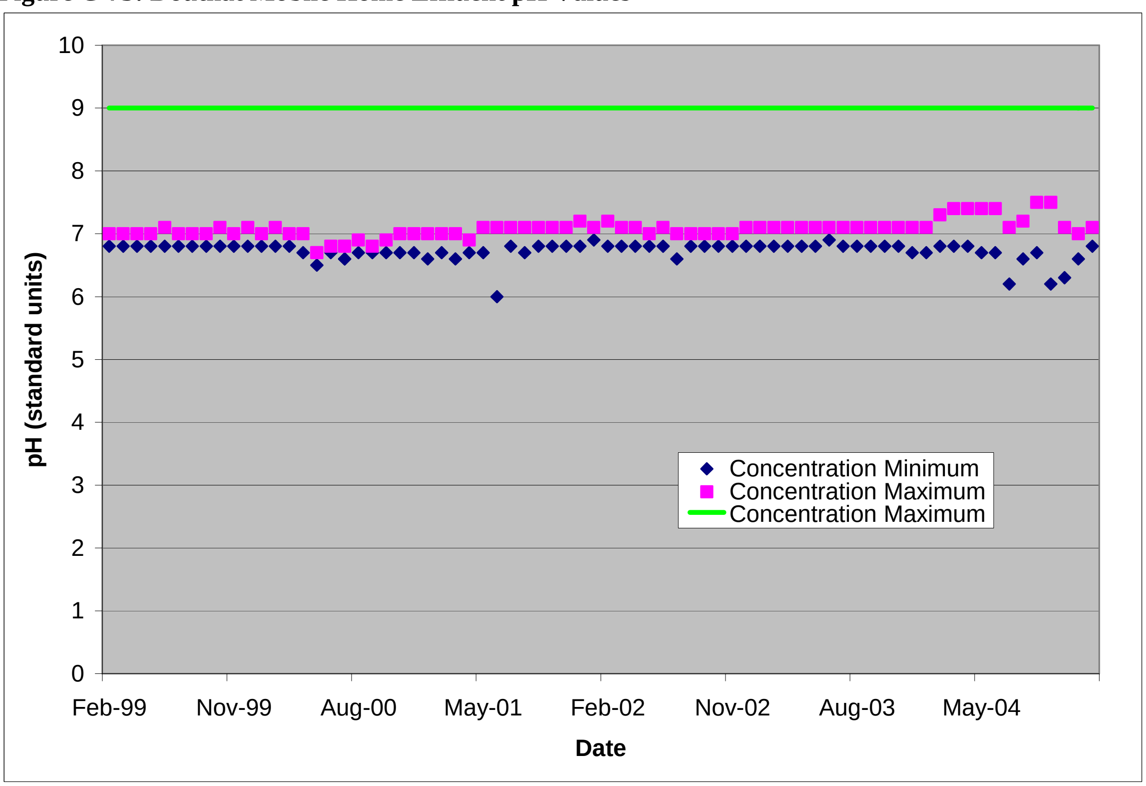


Figure C-76: Douthat Mobile Home Effluent TSS Concentrations

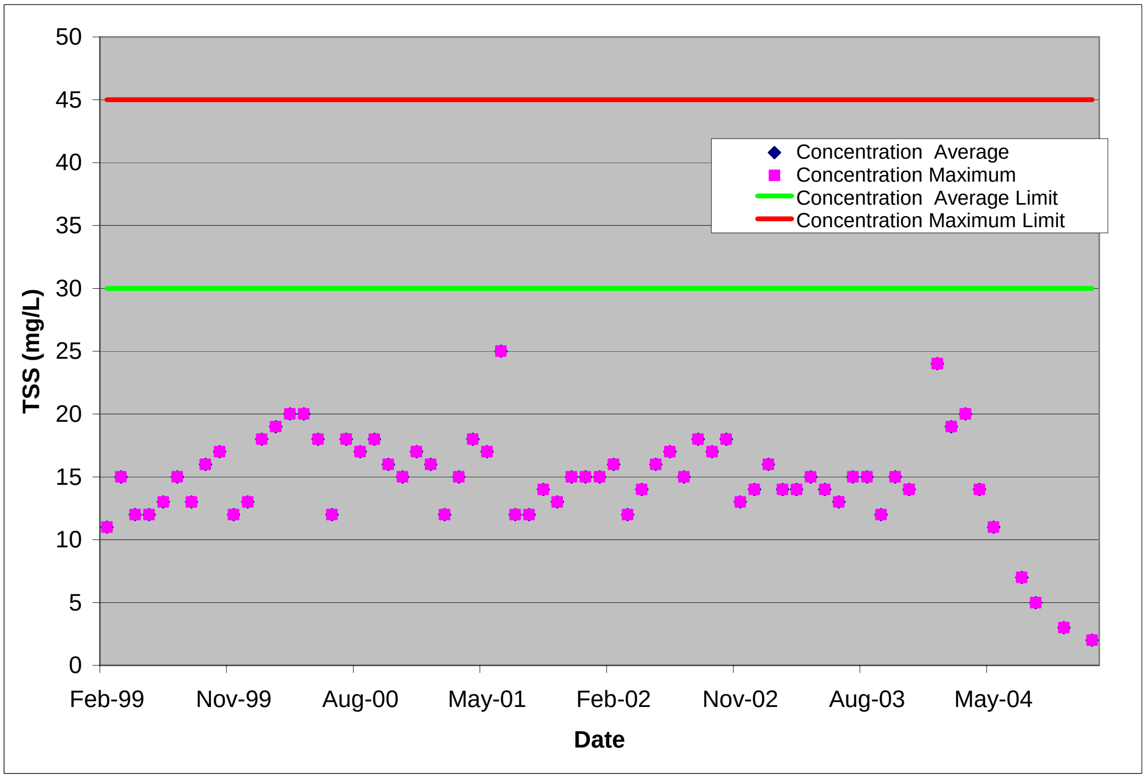


Figure C-77: Douthat Mobile Home Effluent TSS Quantities

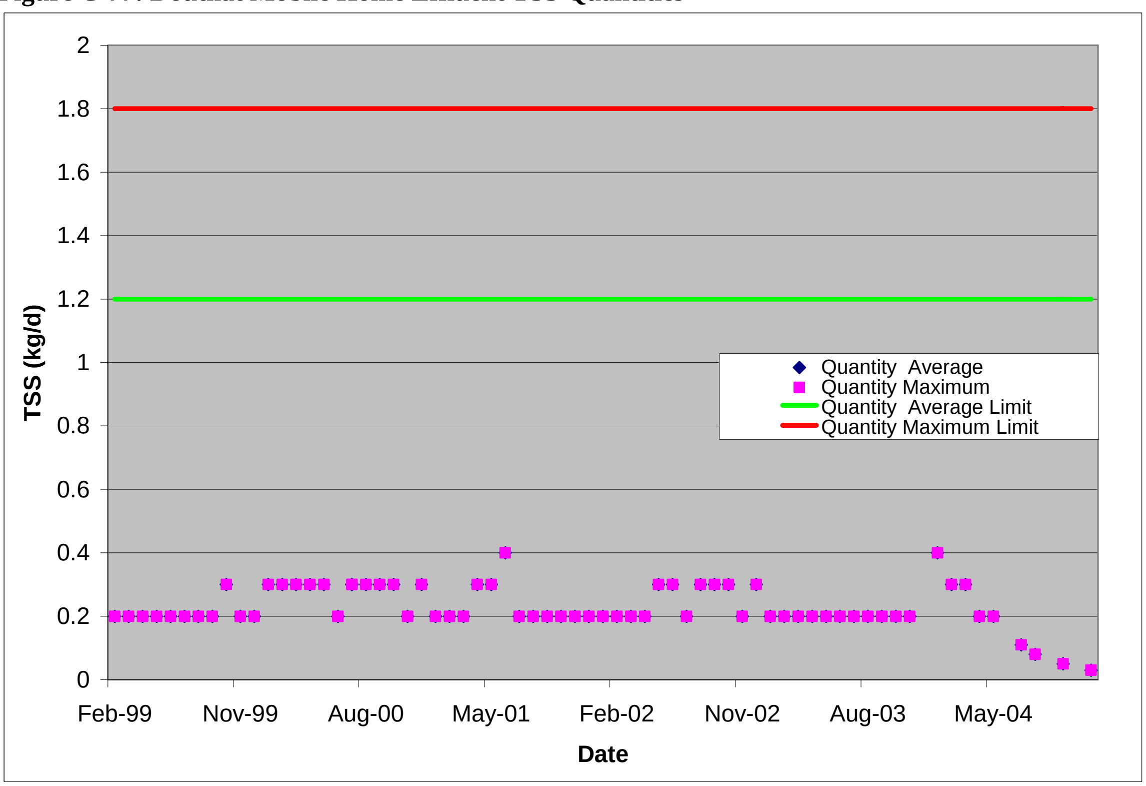


Figure C-78: Douthat Mobile Home Effluent Cl2 Concentrations

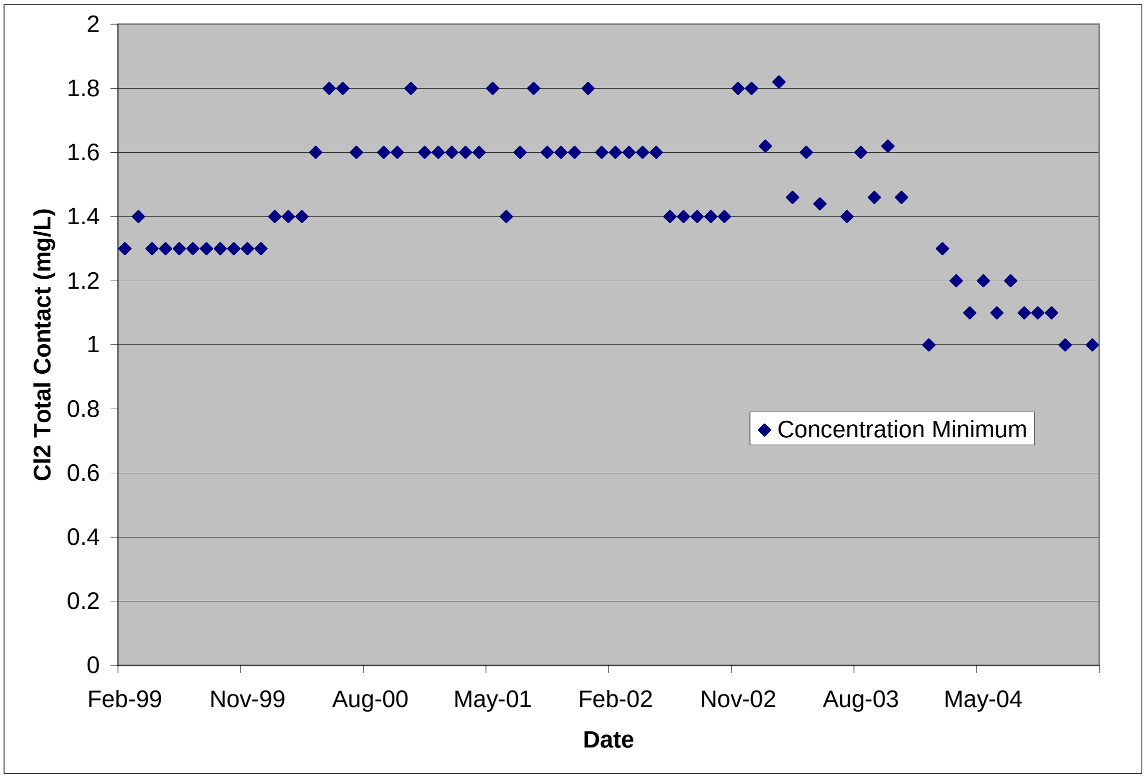


Figure C-79: Douthat Mobile Home Effluent BOD5 Concentrations

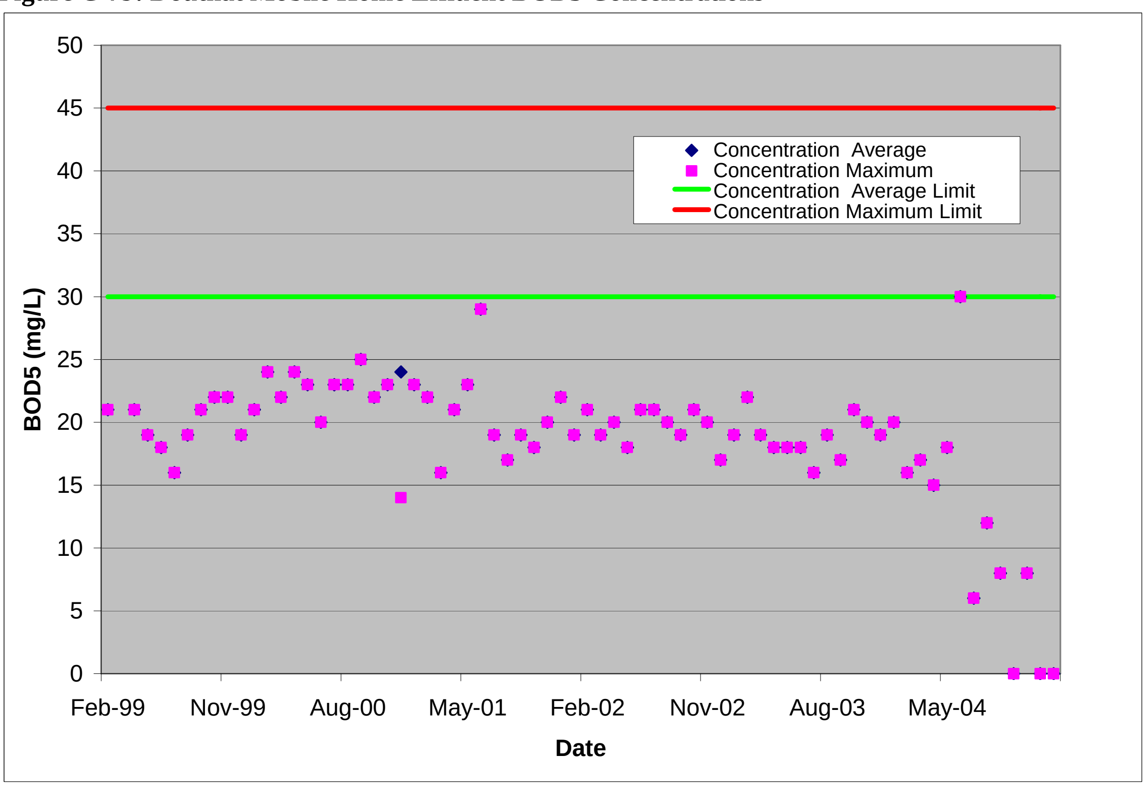


Figure C-80: Douthat Mobile Home Effluent BOD5 Quantities

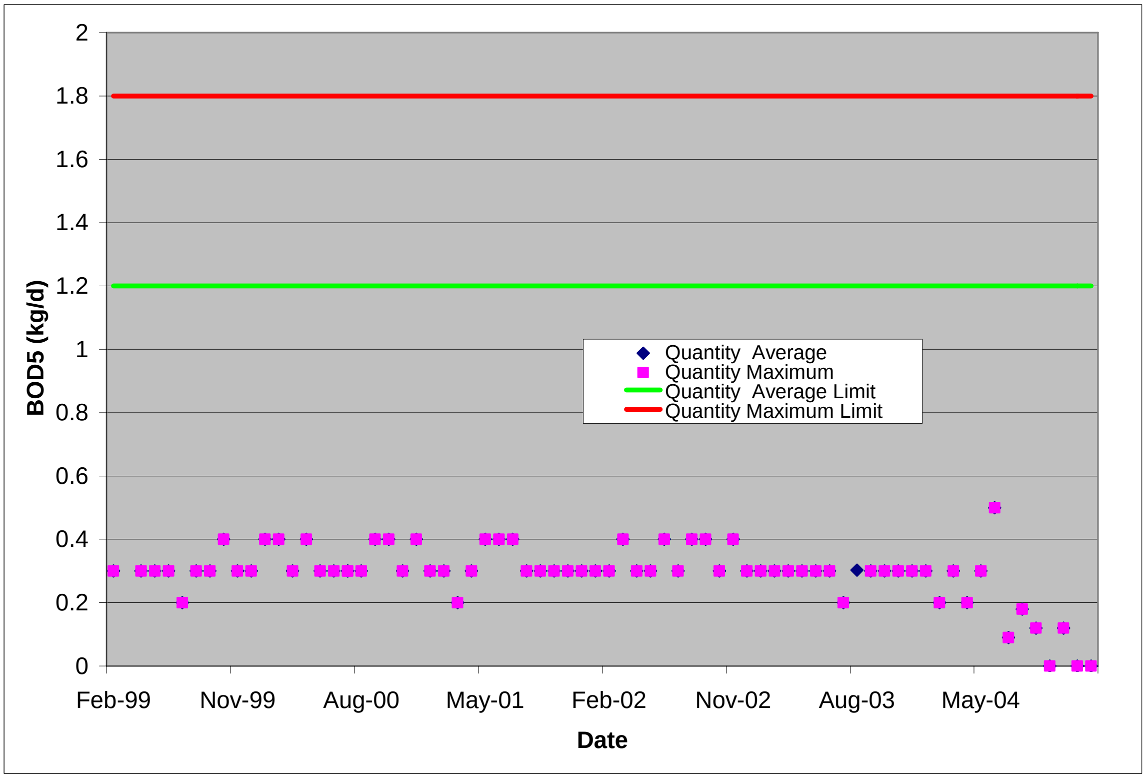


Figure C-81: Douthat Mobile Home Effluent Cl2 Inst Res Max Concentrations

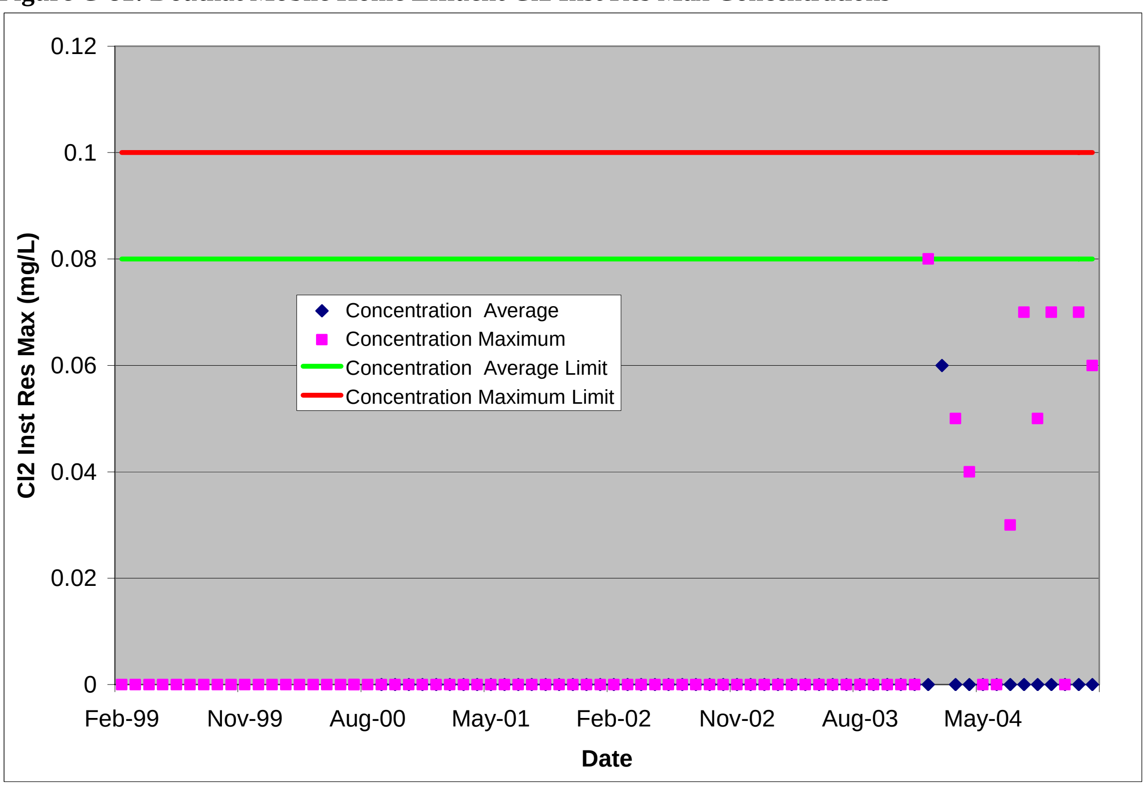


Figure C-82: MeadWestvaco Flow Values from Outfall 1

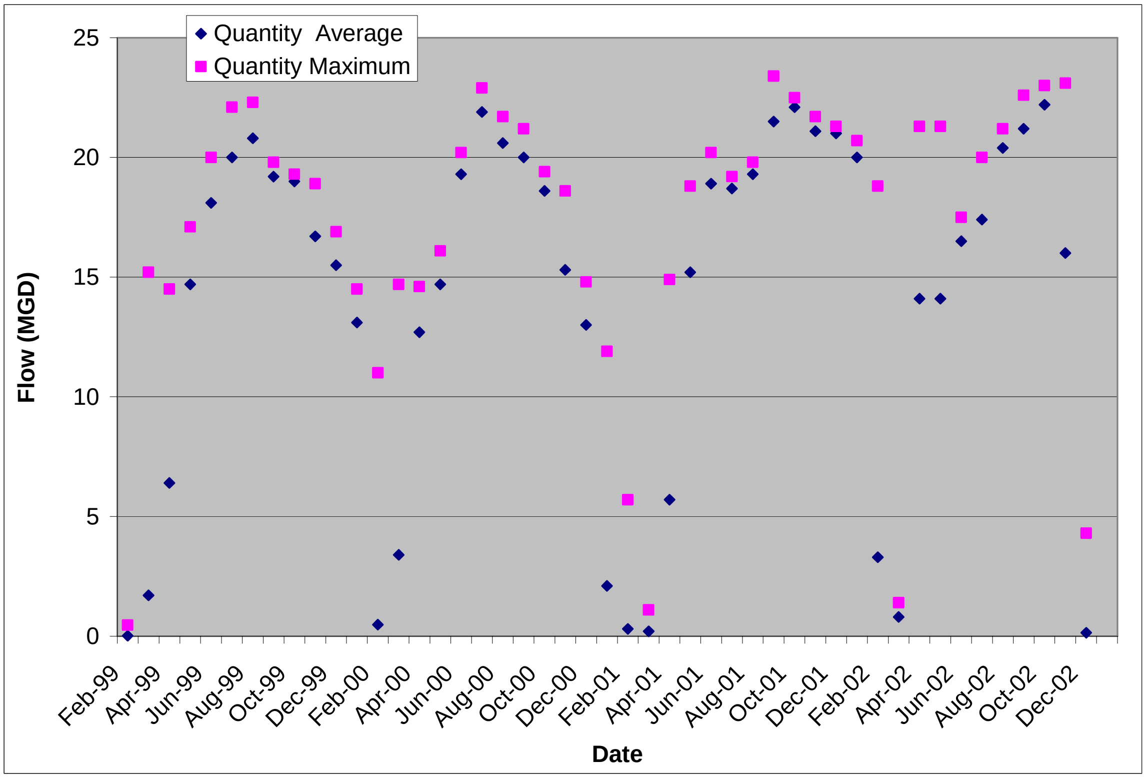


Figure C-83: MeadWestvaco Effluent pH Values from Outfall 1

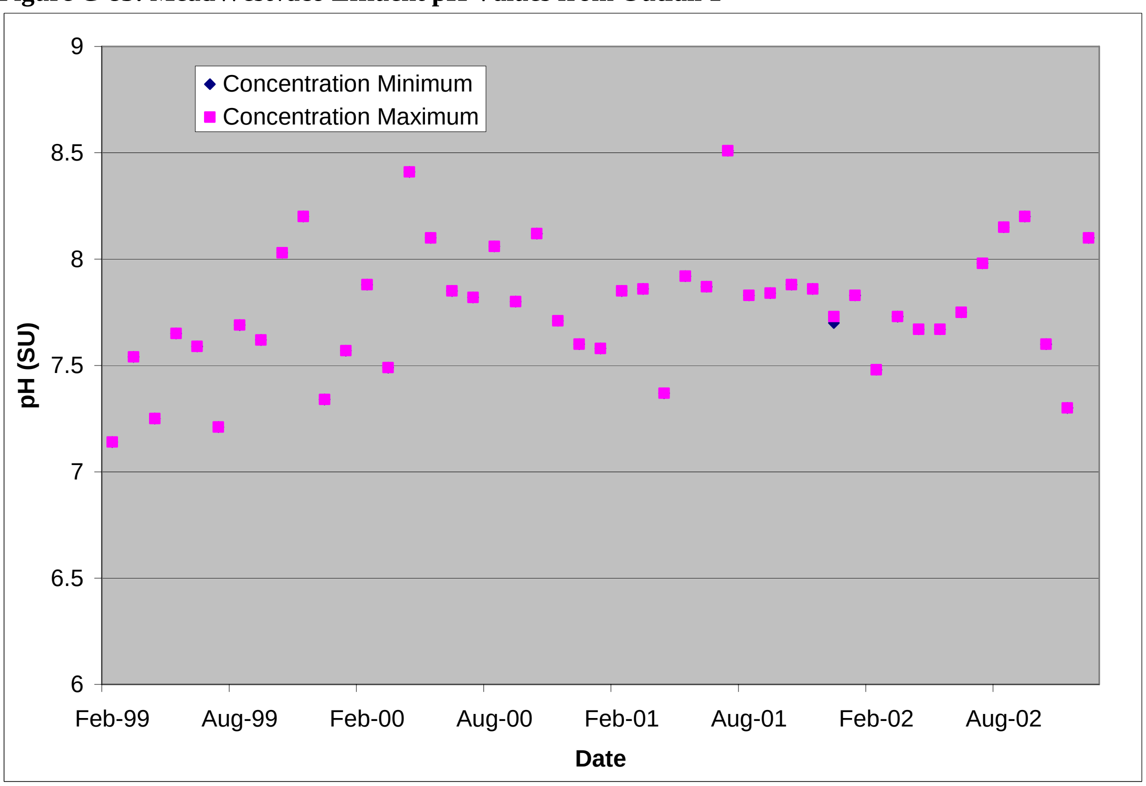


Figure C-84: Mead Westvaco Effluent Temperature Values from Outfall 1

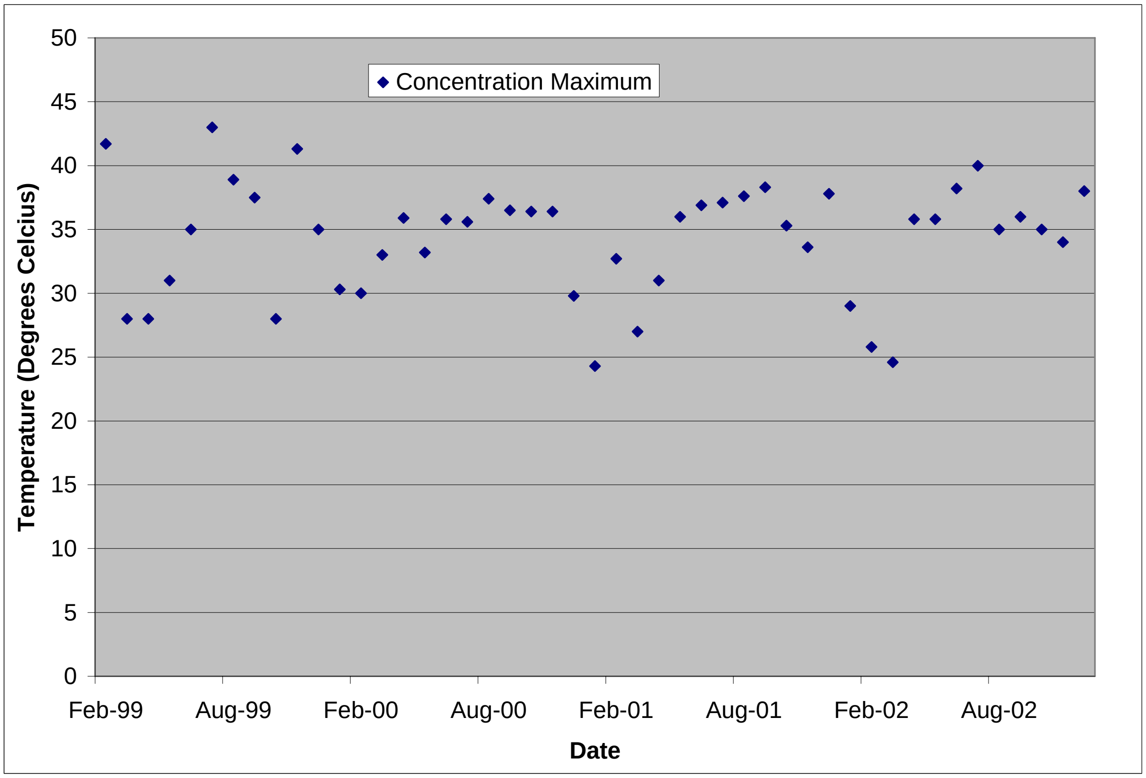


Figure C-85: MeadWestvaco Flow Values from Outfall 2

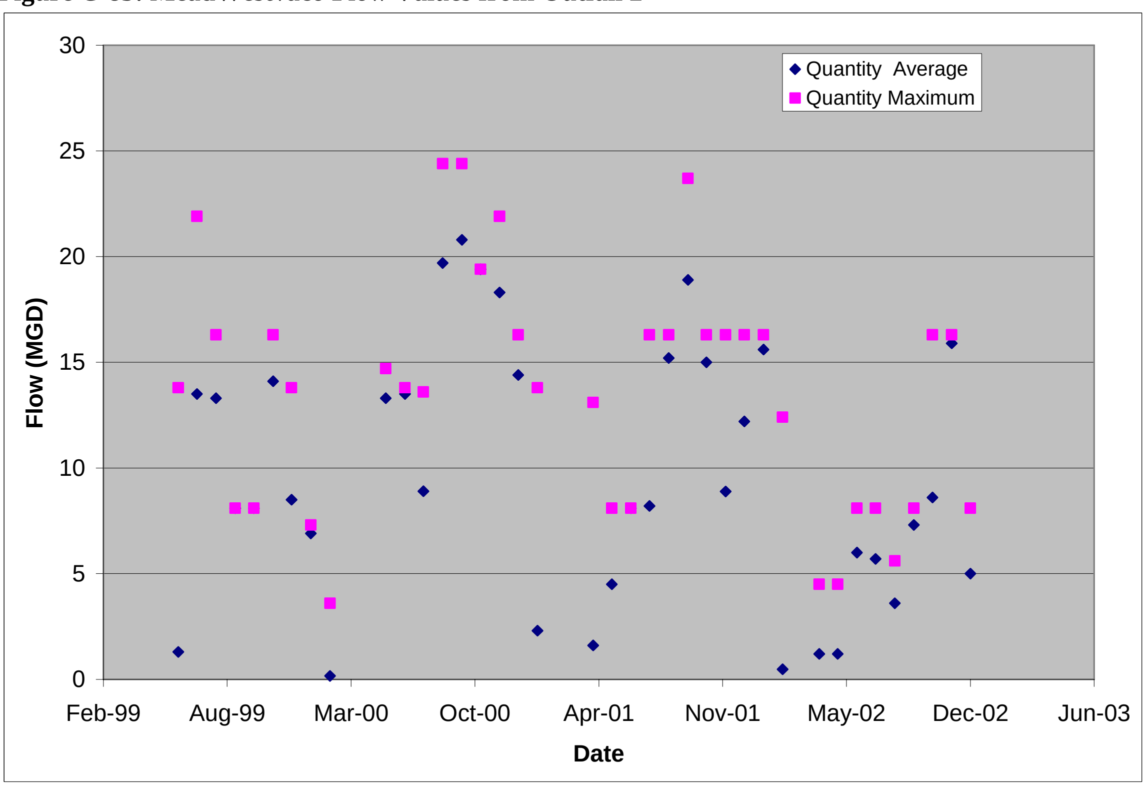


Figure C-86: MeadWestvaco Effluent pH Values from Outfall 2

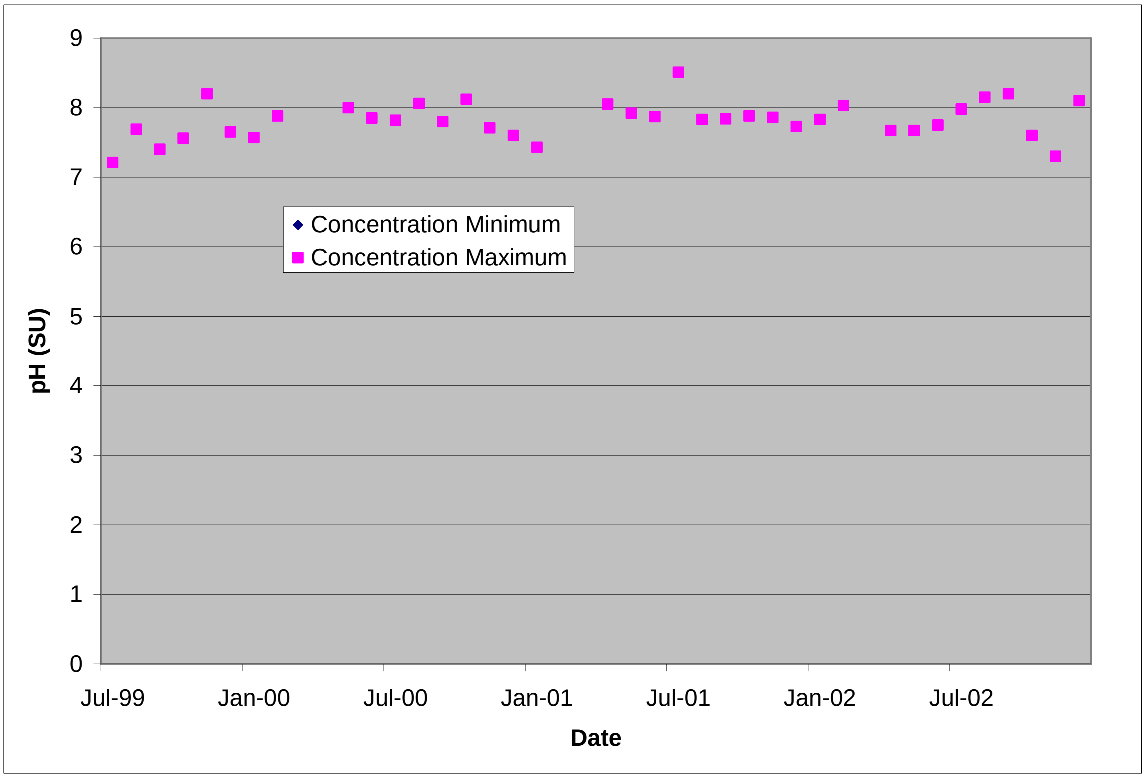


Figure C-87: MeadWestvaco Effluent Temperature Values from Outfall 2

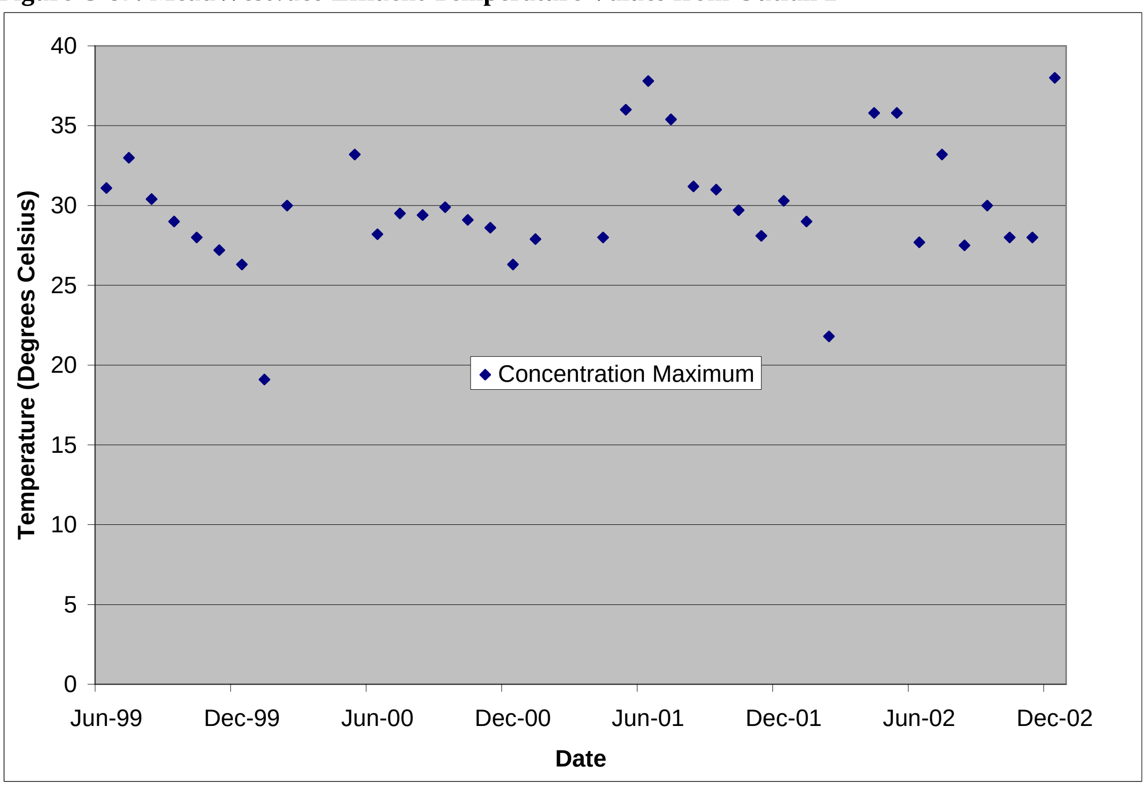


Figure C-88: MeadWestvaco Effluent Flow Values from Outfall 3

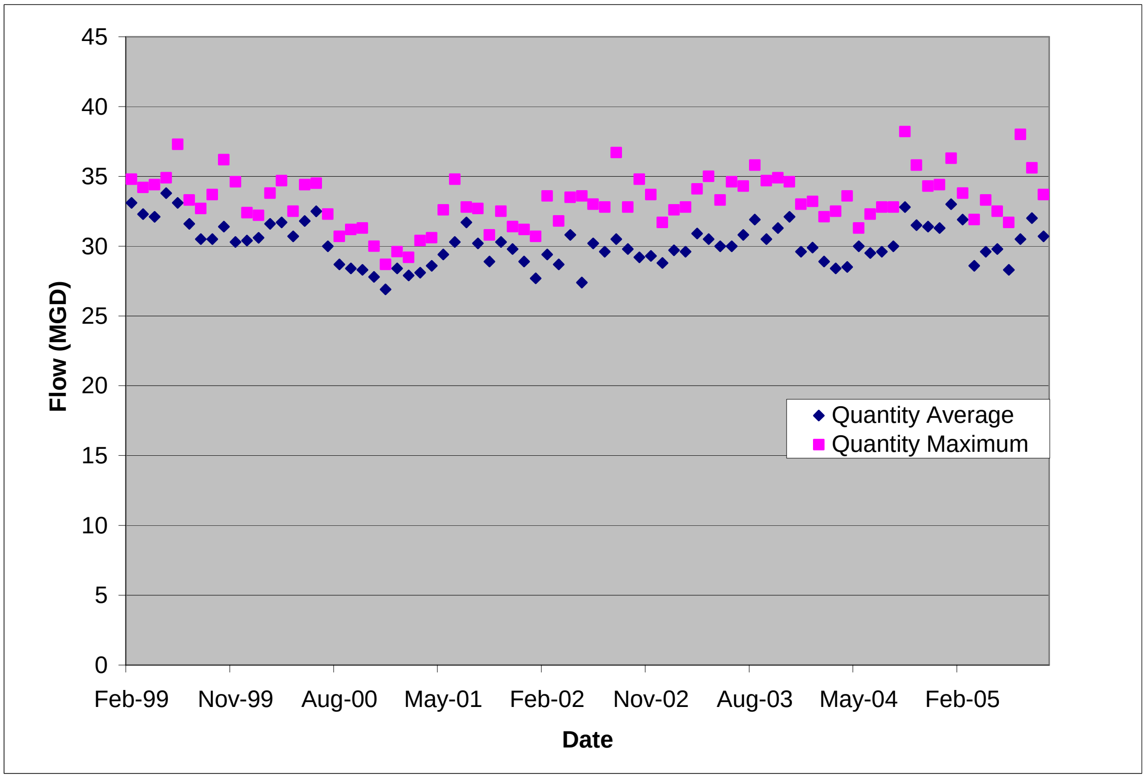


Figure C-89: MeadWestvaco Absorbable Organic Halides Effluent Concentrations from Outfall 3

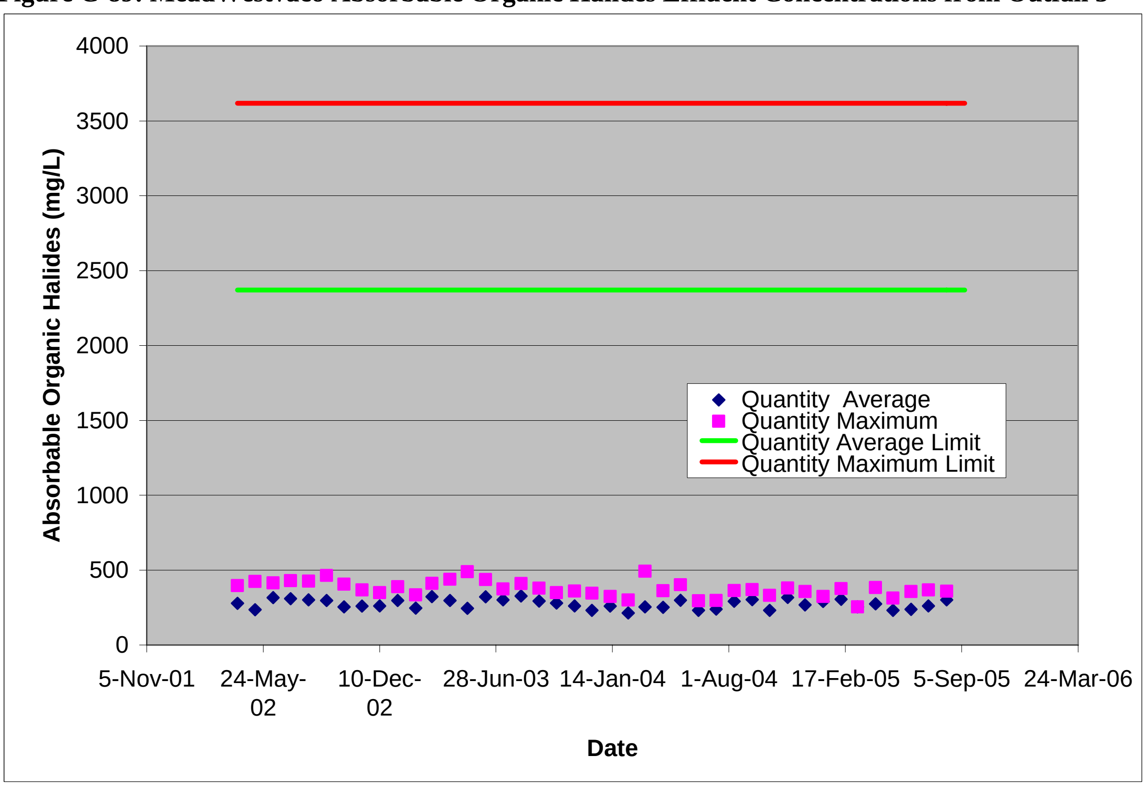


Figure C-90: MeadWestvaco Effluent BOD5 Concentrations from Outfall 3

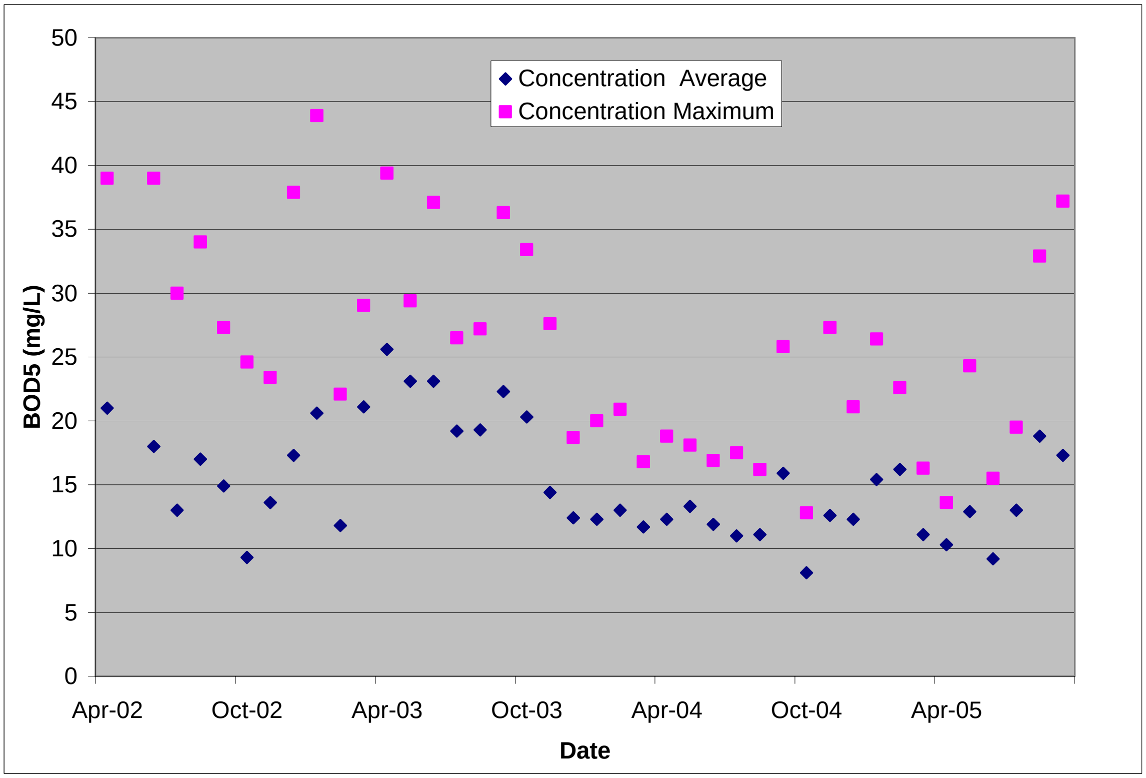


Figure C-91: MeadWestvaco Effluent COD Concentrations from Outfall 3

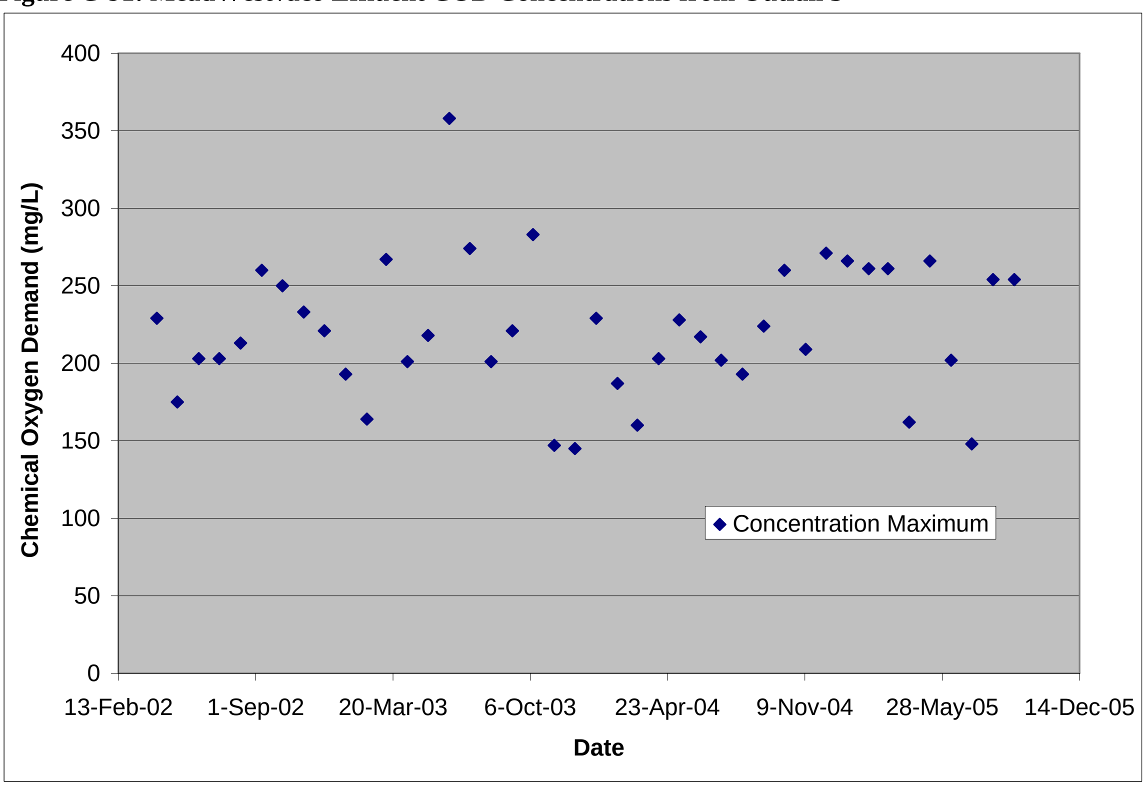


Figure C-92: MeadWestvaco Effluent Color Values from Outfall 3

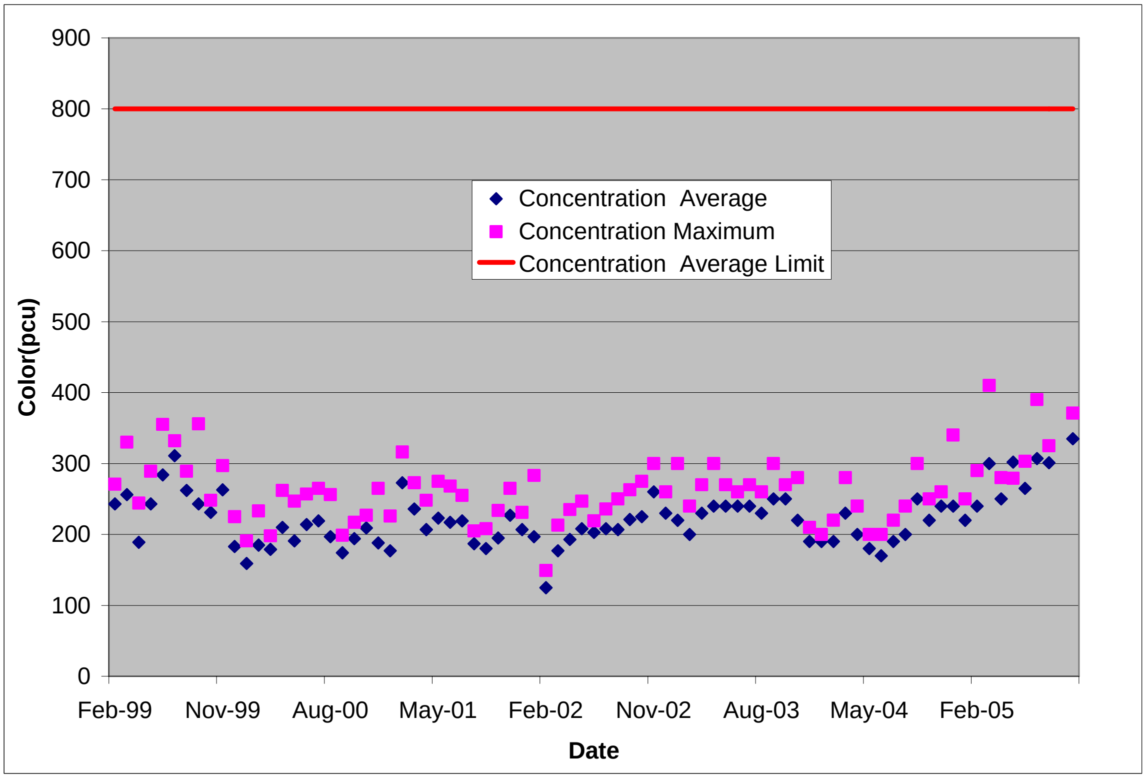


Figure C-93: MeadWestvaco Effluent Nitrogen Concentrations from Outfall 3

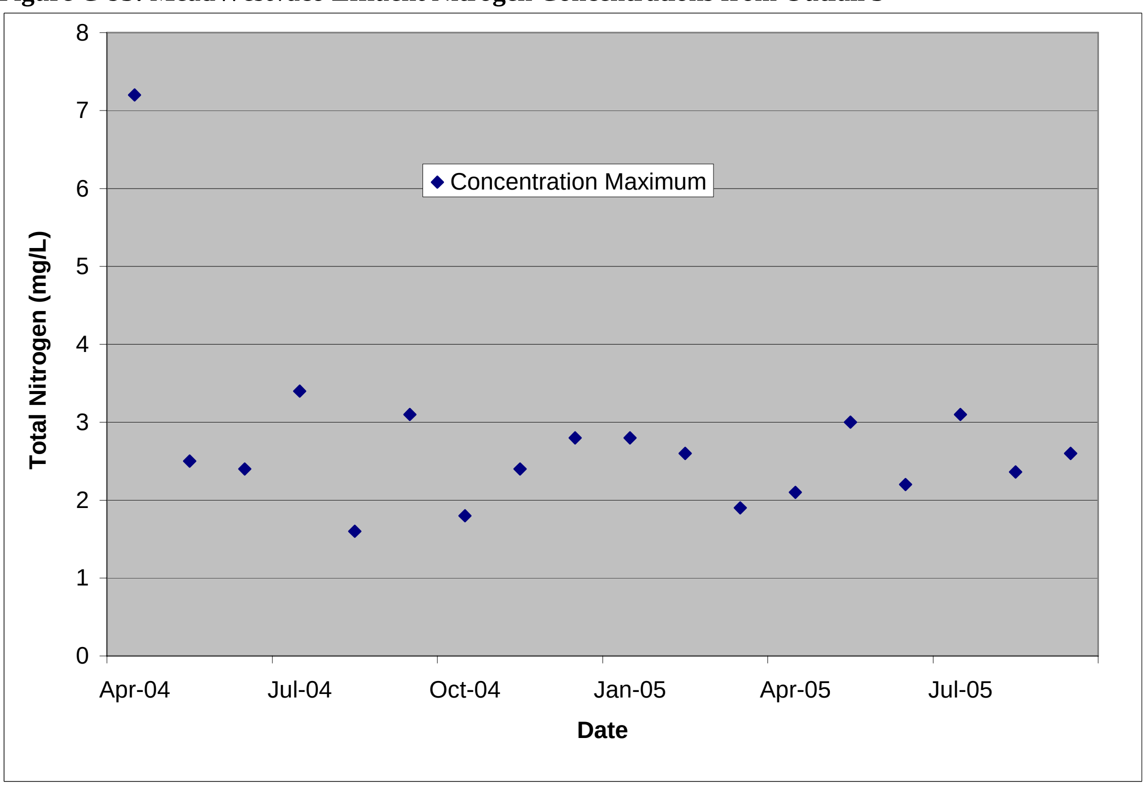


Figure C-94: MeadWestvaco Effluent Total Phosphorous Concentrations from Outfall 3

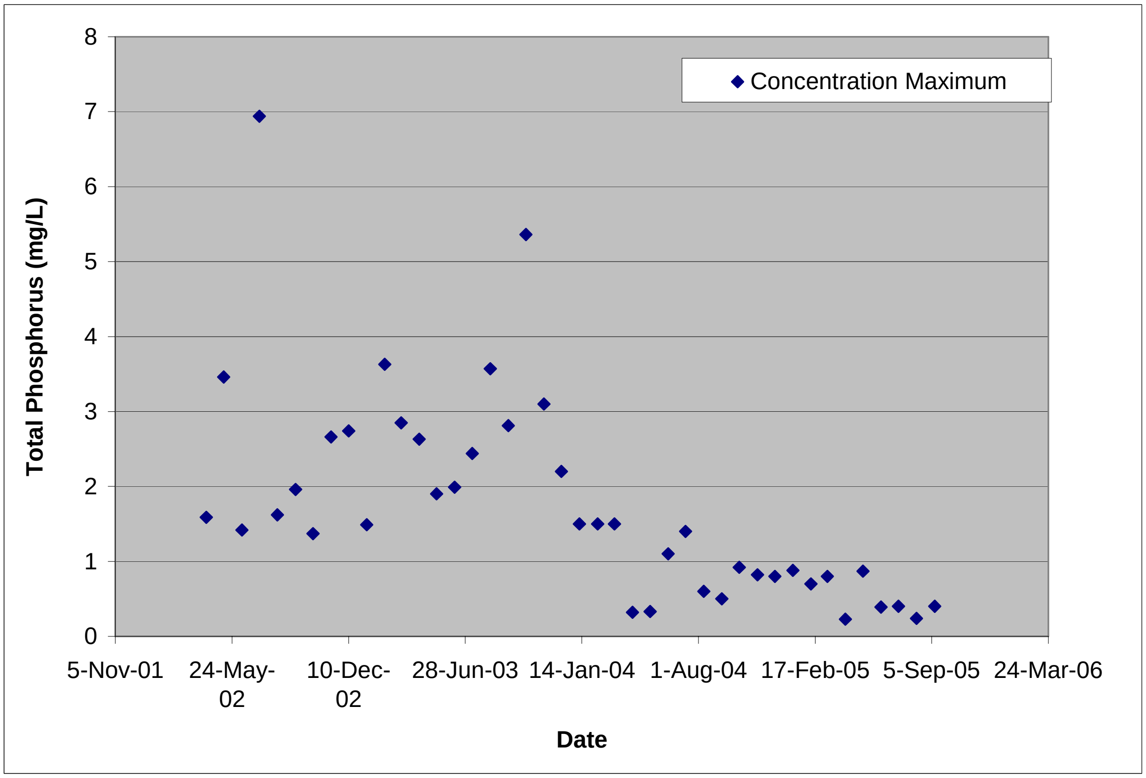


Figure C-95: MeadWestvaco Effluent pH Values from Outfall 3

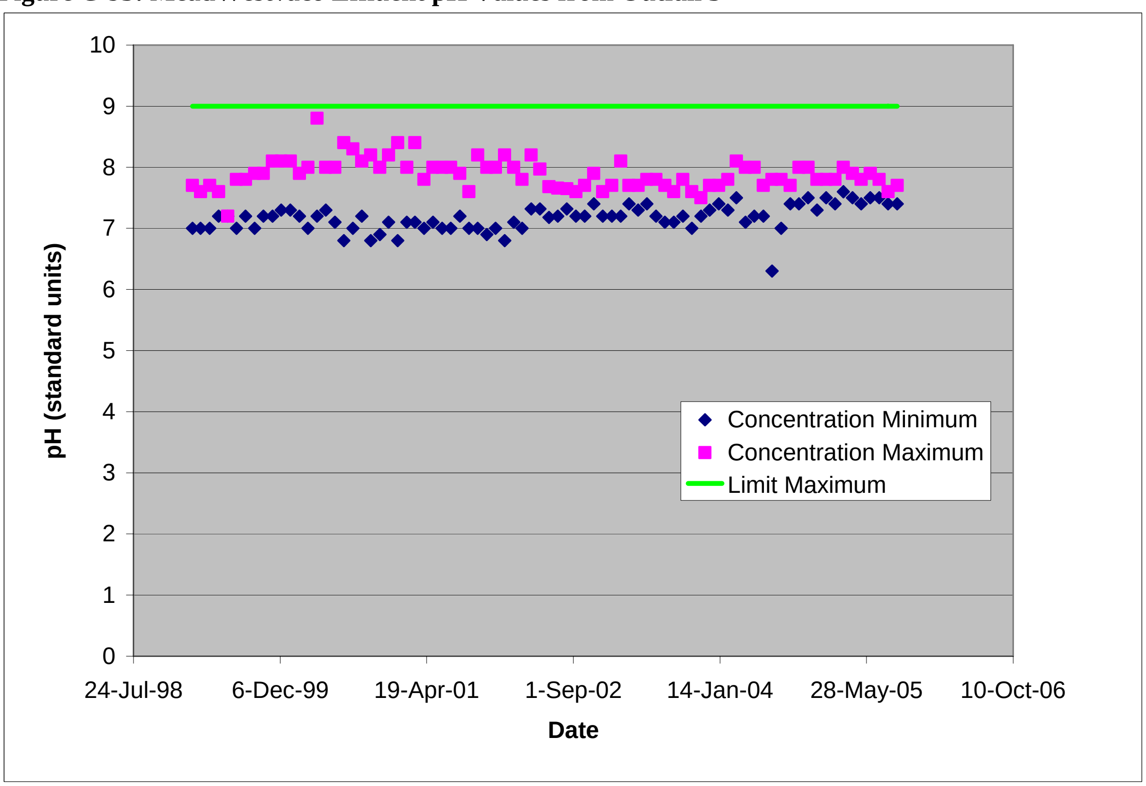


Figure C-96: MeadWestvaco Effluent Temperature Values from Outfall 3

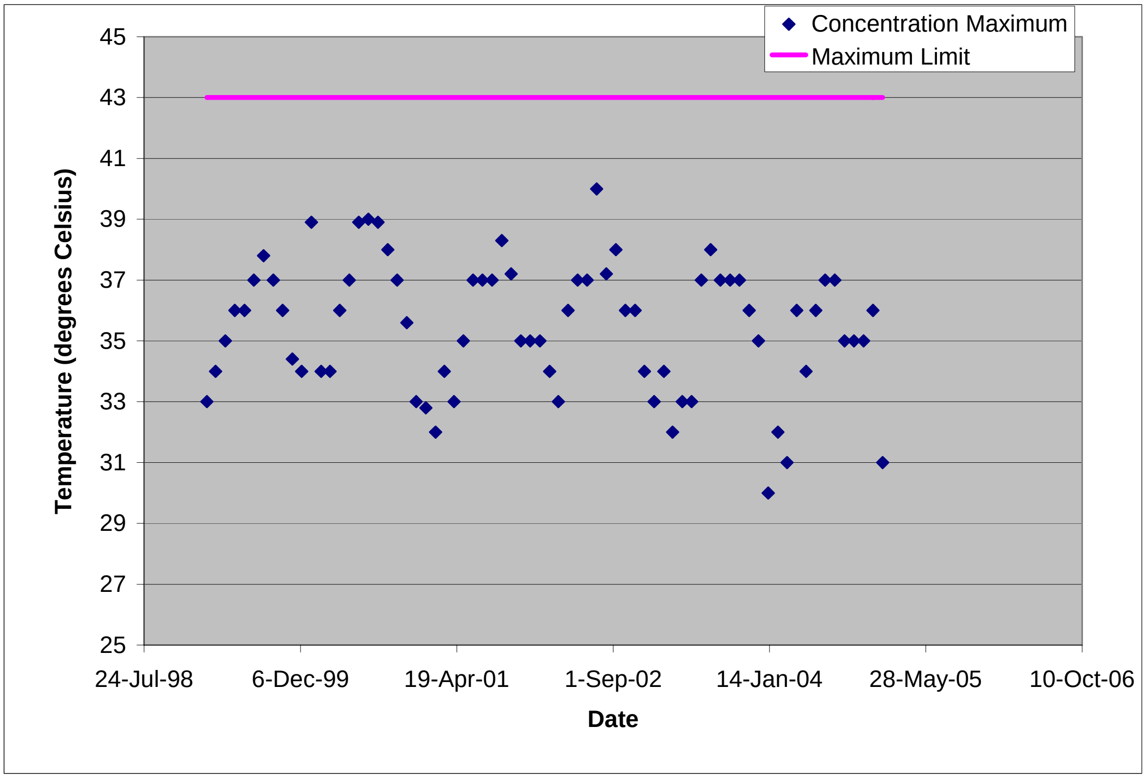


Figure C-97: MeadWestvaco Effluent TSS Quantities from Outfall 3

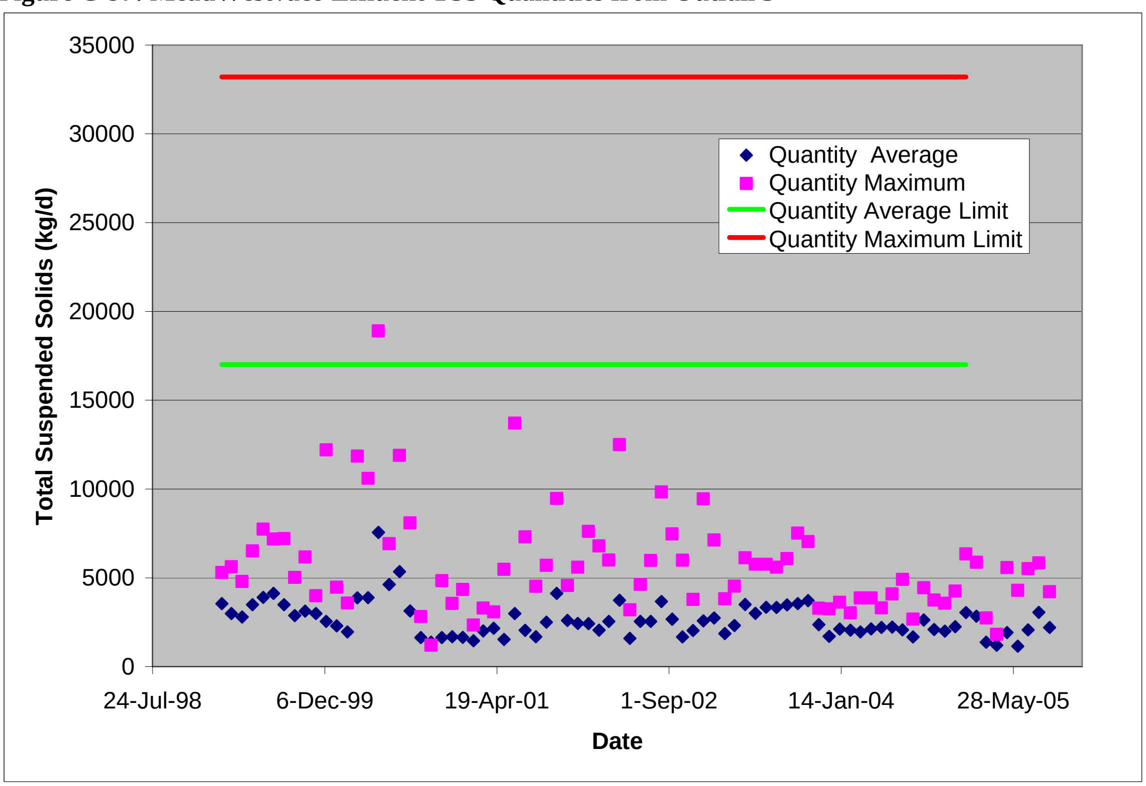


Figure C-98: MeadWestvaco Effluent Fecal Coliform Concentrations from Outfall 3

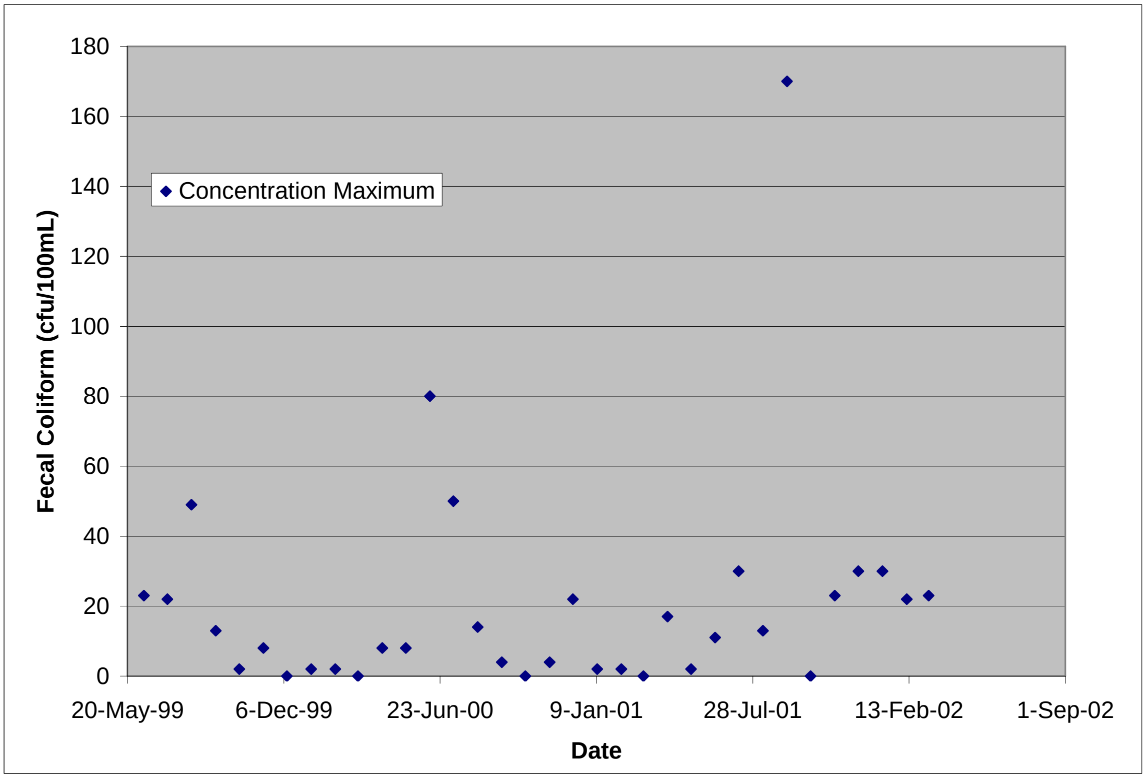


Figure C-99: MeadWestvaco Effluent Ammonia Concentrations from Outfall 3

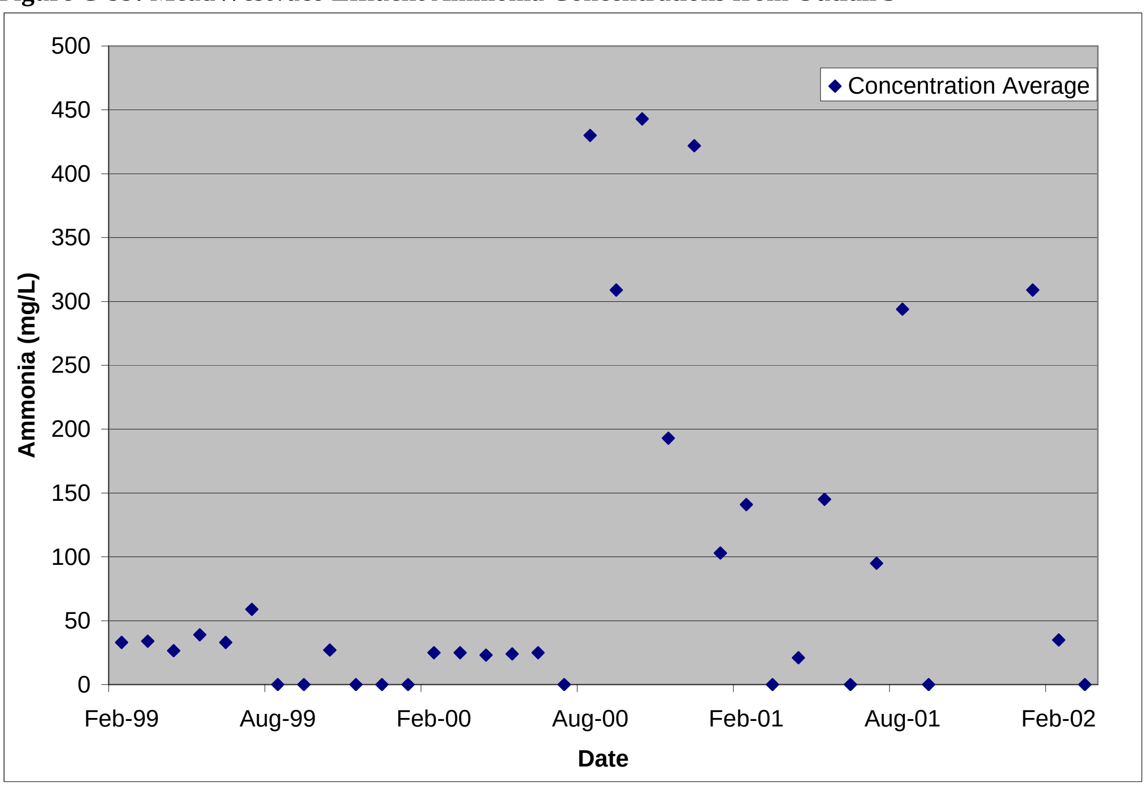


Figure C-100: MeadWestvaco Effluent Flow Values From Outfall 4

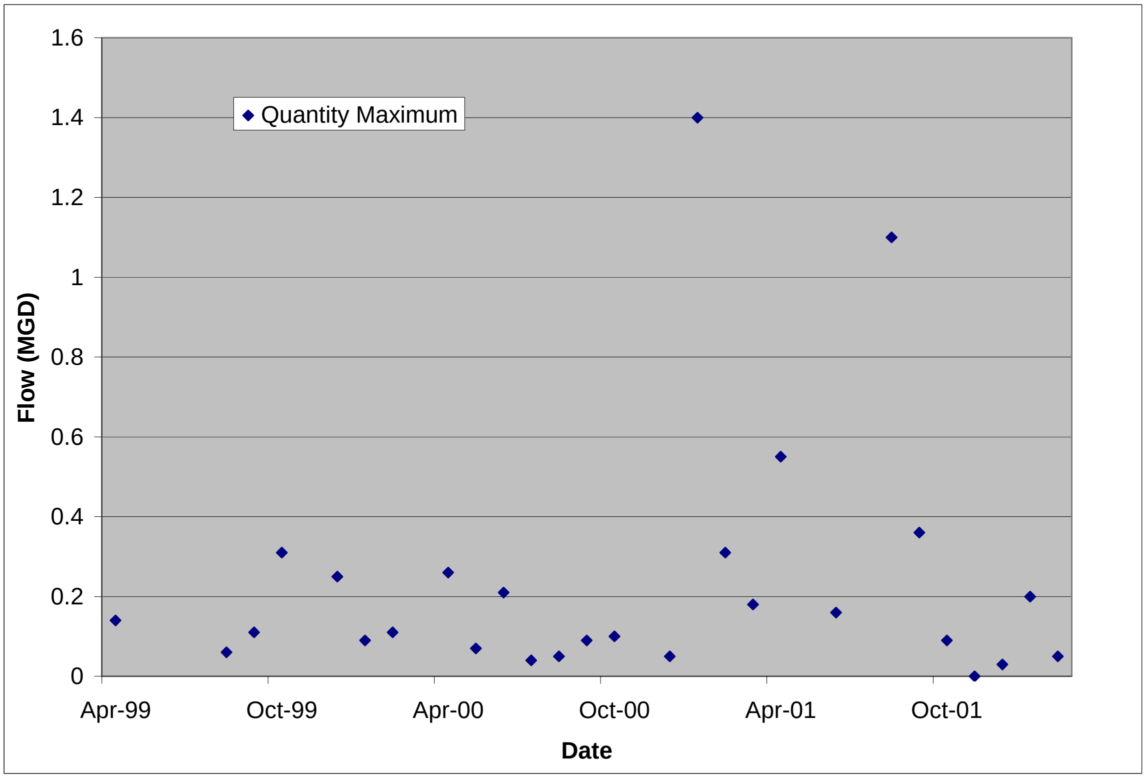


Figure C-101: Mead Westvaco Effluent Total Recoverable Iron from Outfall 4

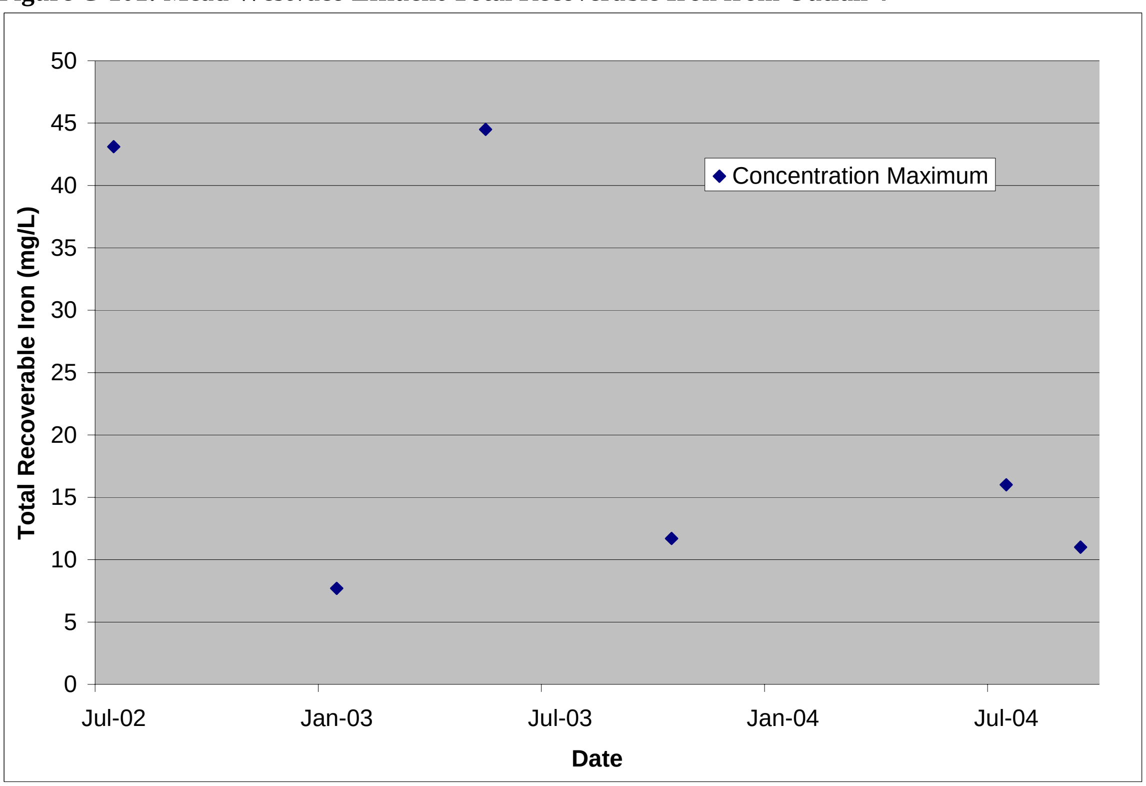


Figure C-102: MeadWestvaco Effluent BOD5 Values from Outfall 4

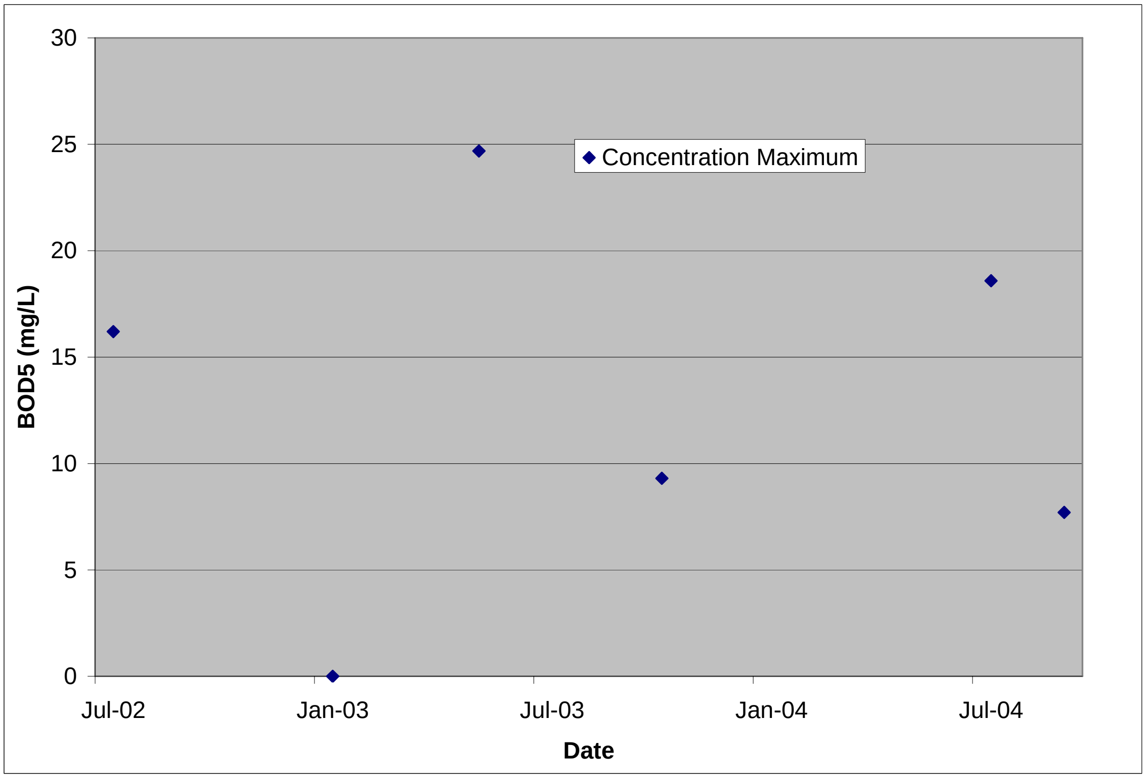


Figure C-103: MeadWestvaco Effluent COD Concentrations from Outfall 4

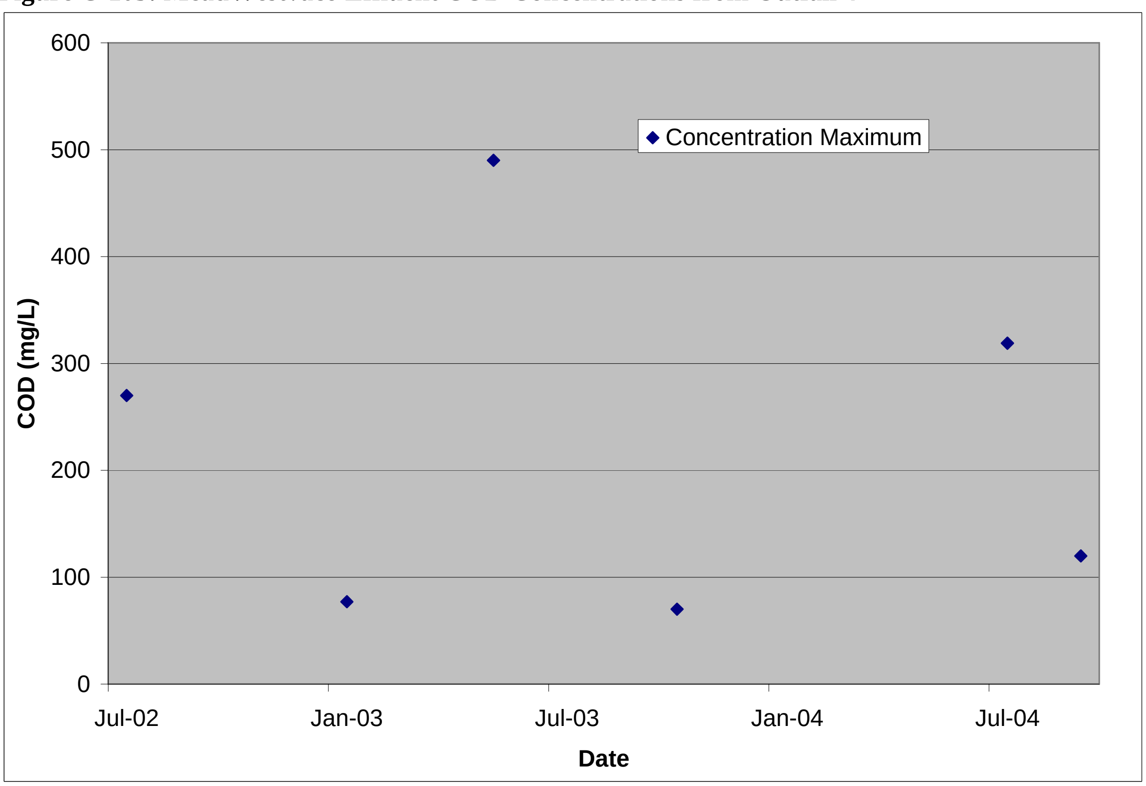


Figure C-104: MeadWestvaco Effluent Total Suspended Solid Concentrations from Outfall 4

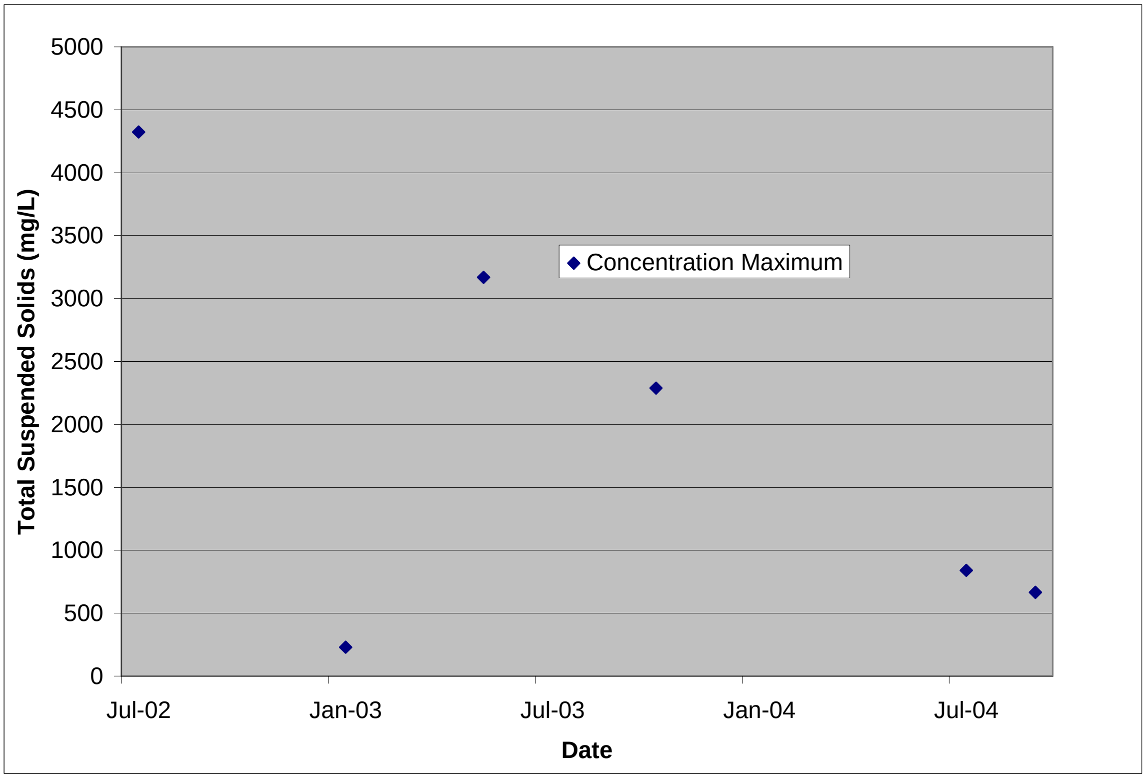


Figure C-105: MeadWestvaco Effluent Chloroform Quantities from Outfall 301

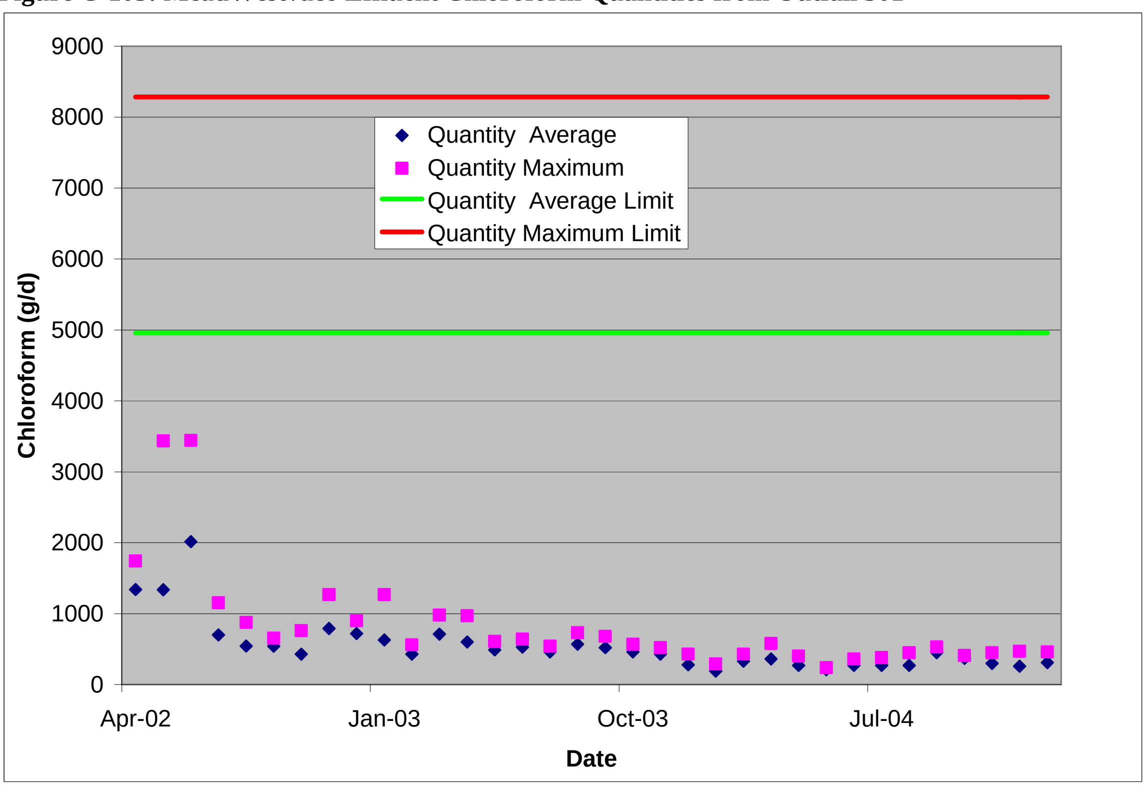


Figure C-106: MeadWestvaco Effluent Chloroform Quantities from Outfall 302

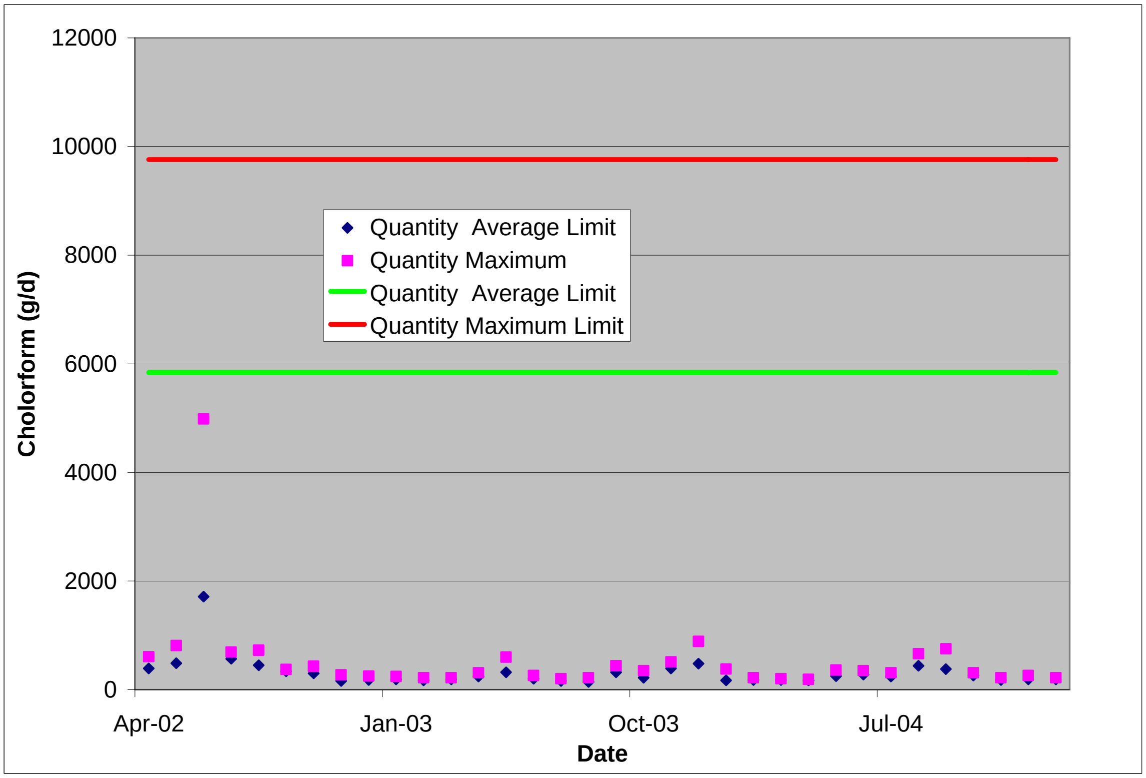


Figure C-107: MeadWestvaco Effluent Chloroform Quantities from Outfall 303

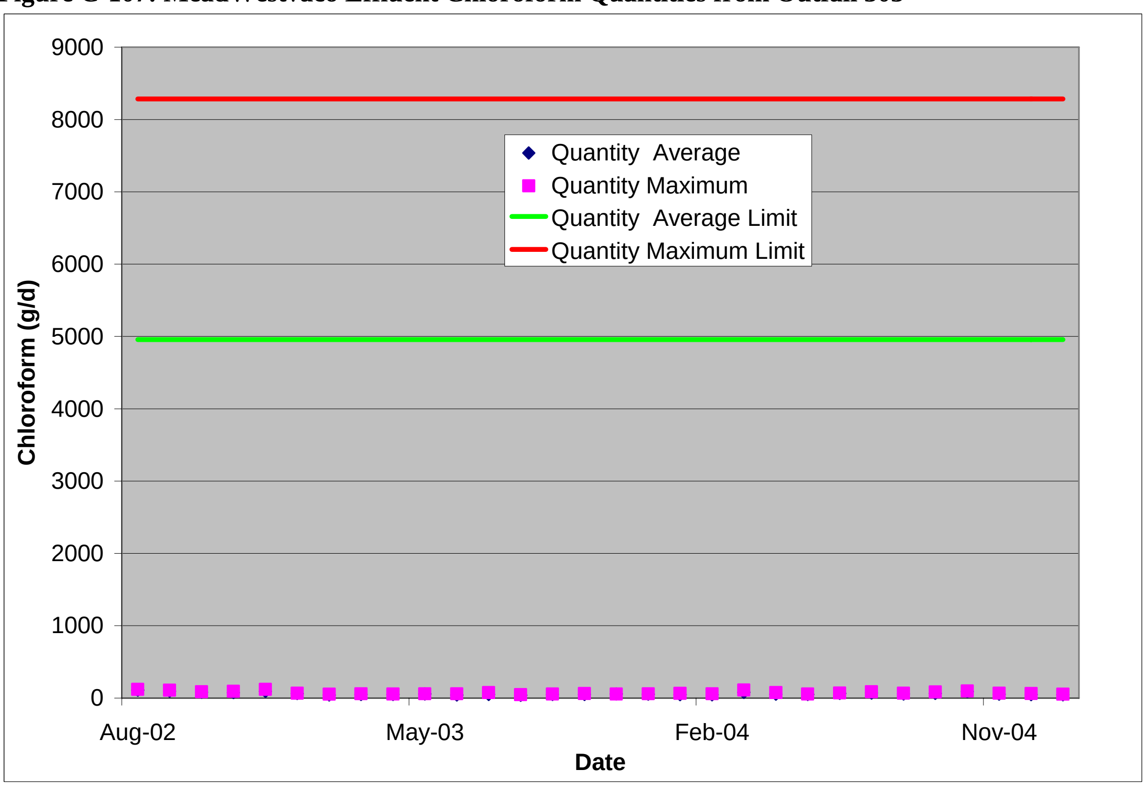


Figure C-108: MeadWestvaco Effluent Heat Values from Outfall 999

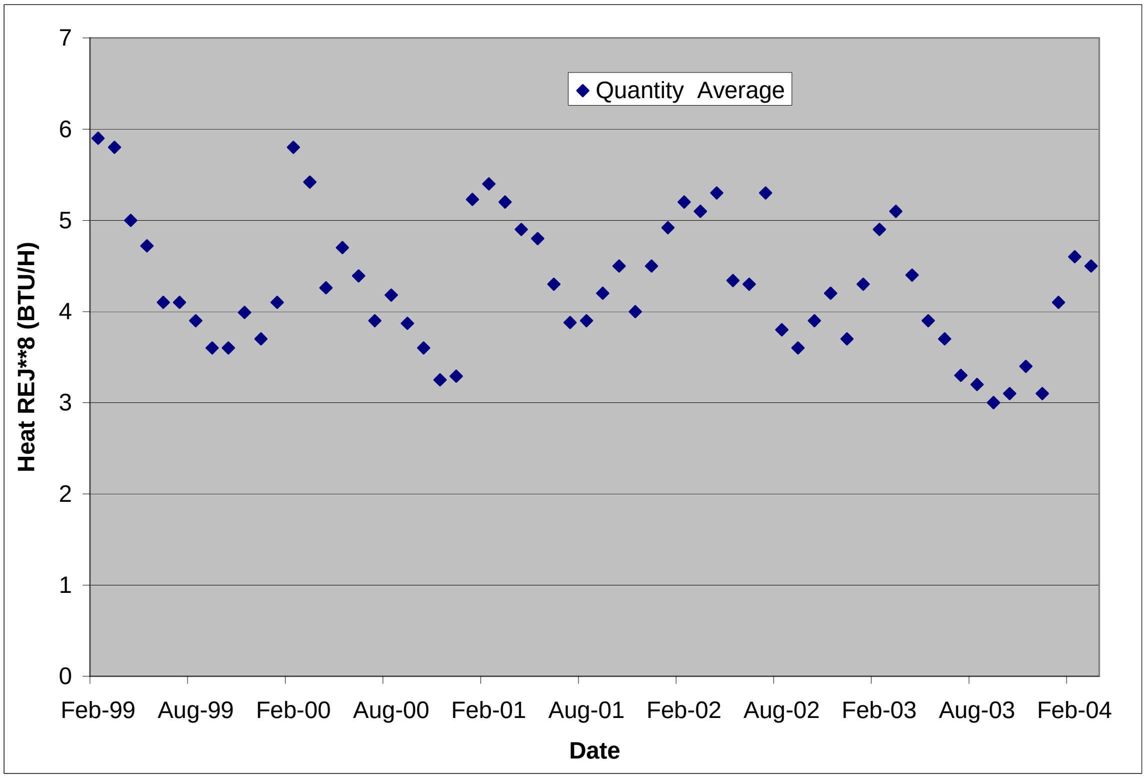


Figure C-109: Morris Hill STP Effluent Flow Values

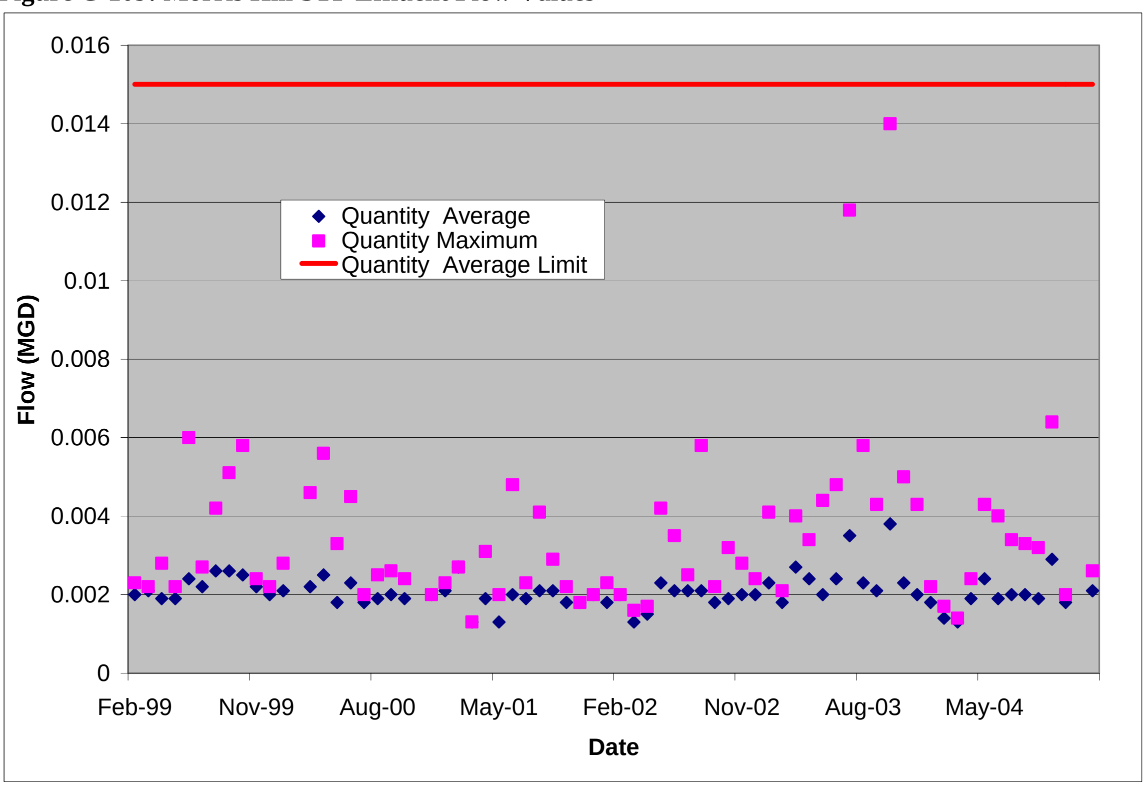


Figure C-110: Morris Hill STP Effluent Dissolved Oxygen Concentrations

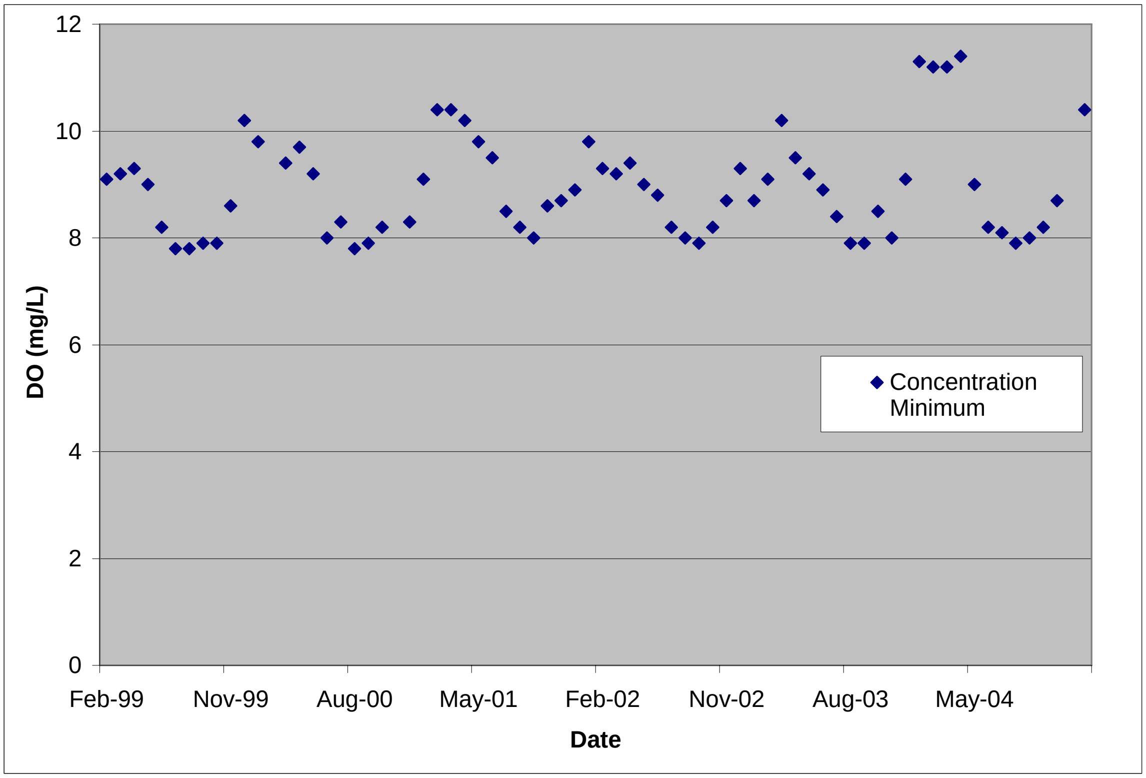


Figure C-111: Morris Hill STP Effluent Inst. Res. Max. CL2 Concentrations

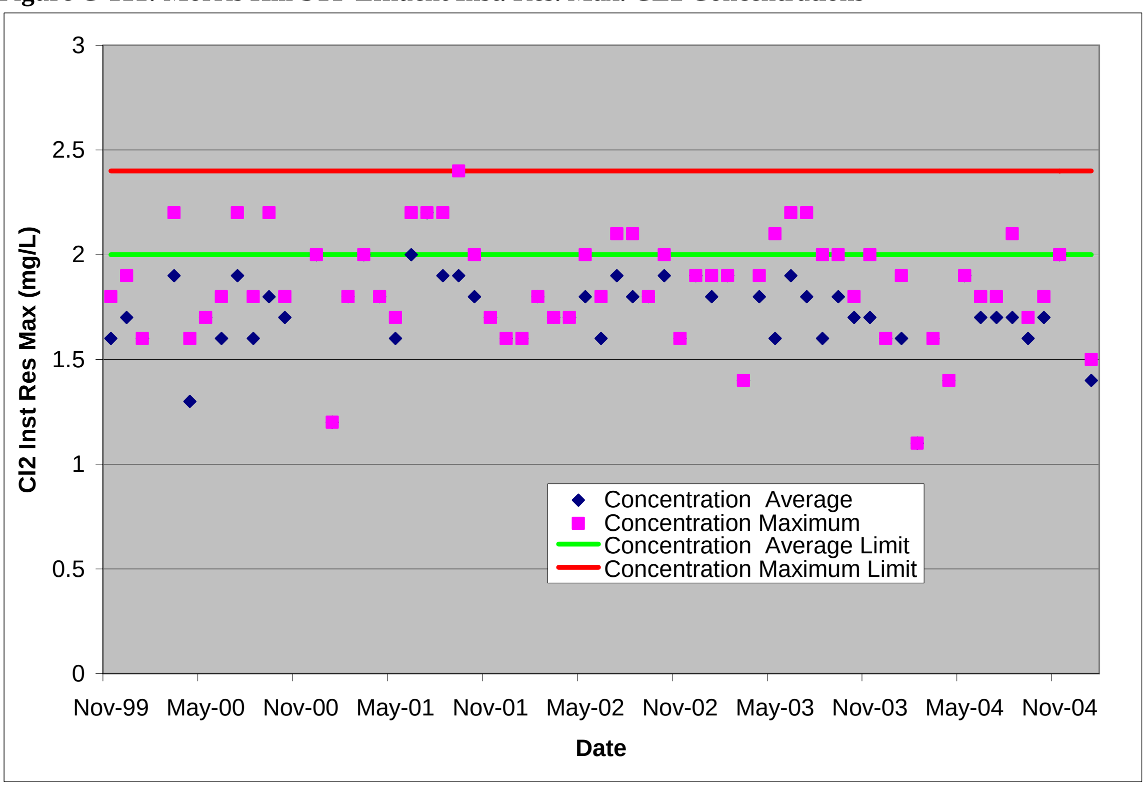


Figure C-112: Morris Hill STP Effluent TSS Concentrations

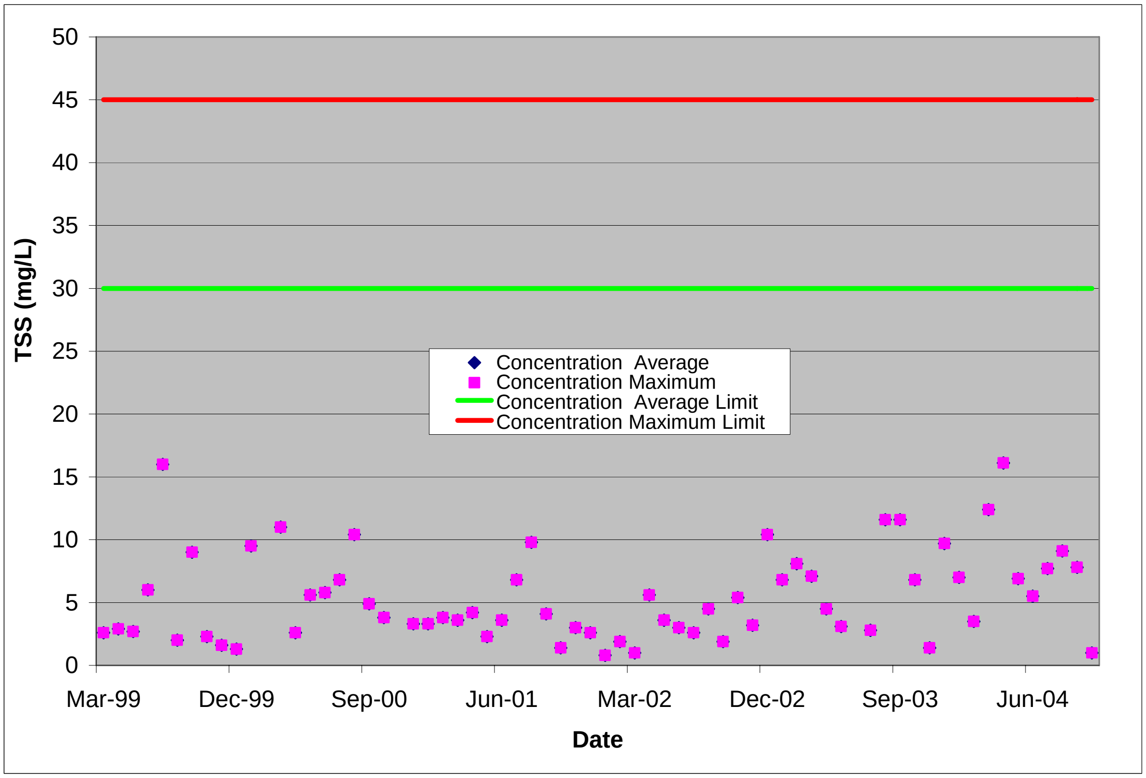


Figure C-113: Morris Hill STP Effluent pH Values

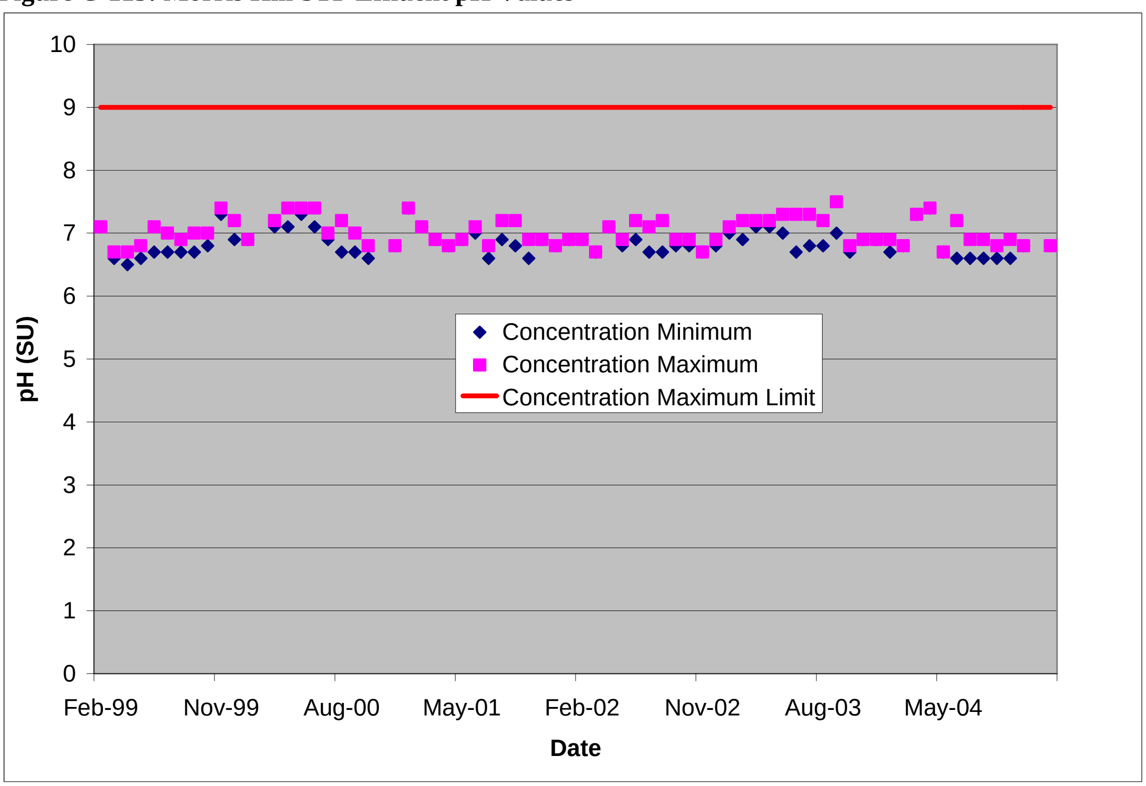


Figure C-114: Morris Hill STP Effluent BOD5 Quantities

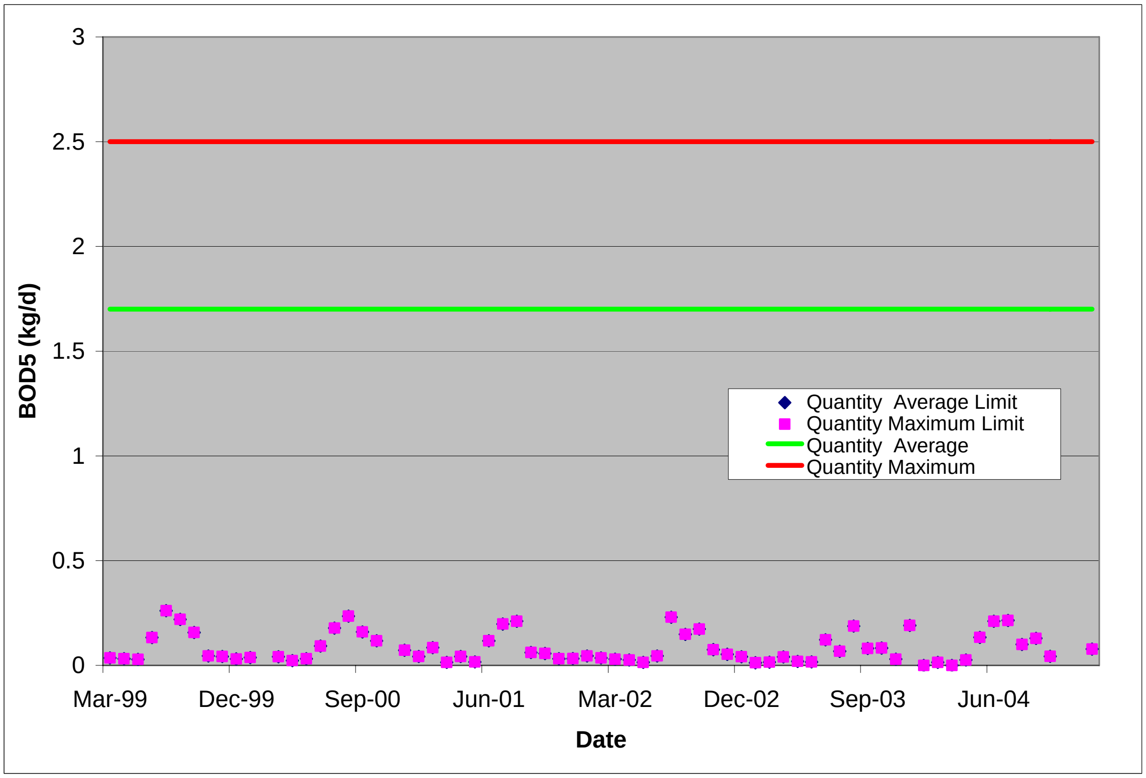


Figure C-115: Morris Hill STP Effluent BOD5 Concentrations

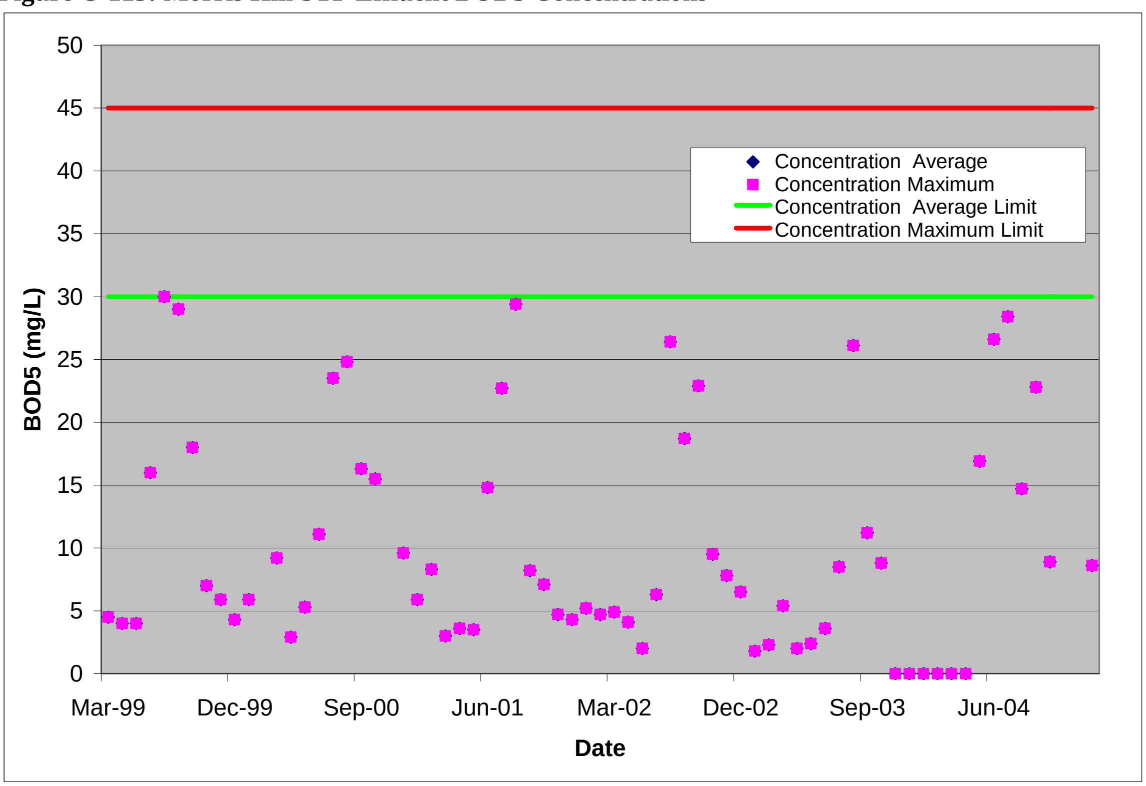


Figure C-116: Parker Hannifin Powertrain Division Effluent Flow Values from Outfall 1

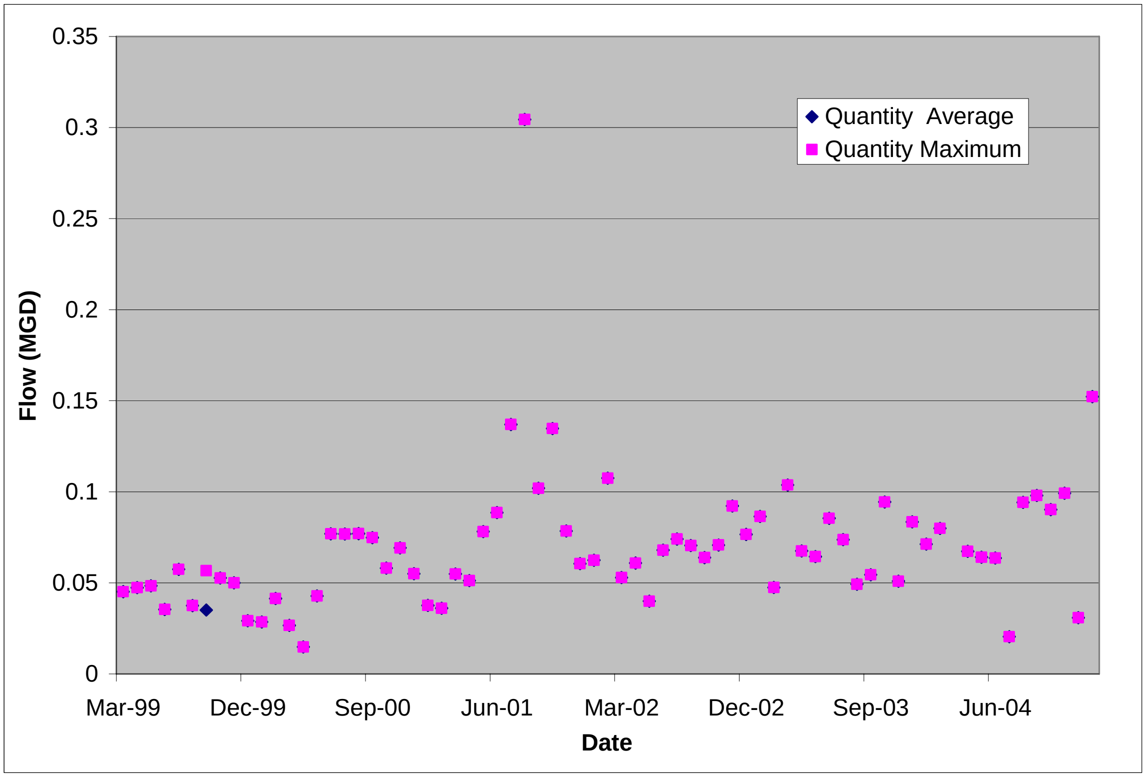


Figure C-117: Parker Hannifin Powertrain Division Effluent pH Values from Outfall 1

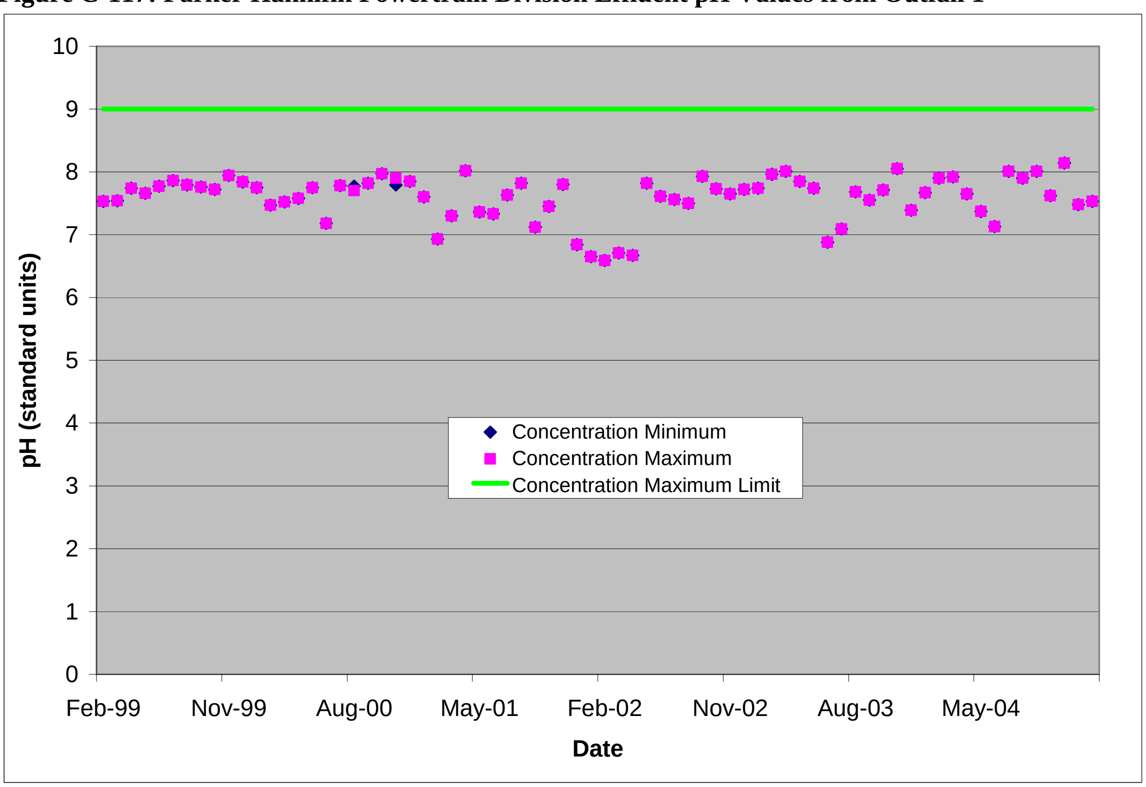


Figure C-118: Parker Hannifin Powertrain Division Effluent Temperature Values from Outfall 1

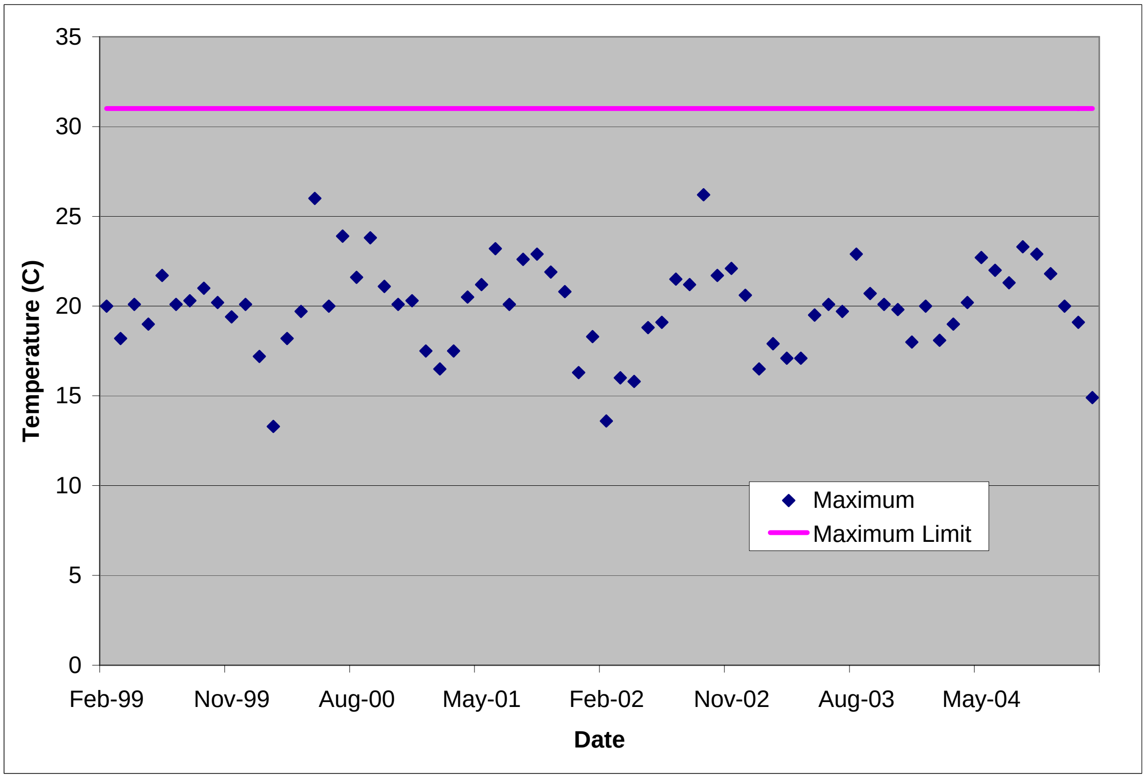


Figure C-119: Parker Hannifin Powertrain Division Effluent Flow Values from Outfall 2

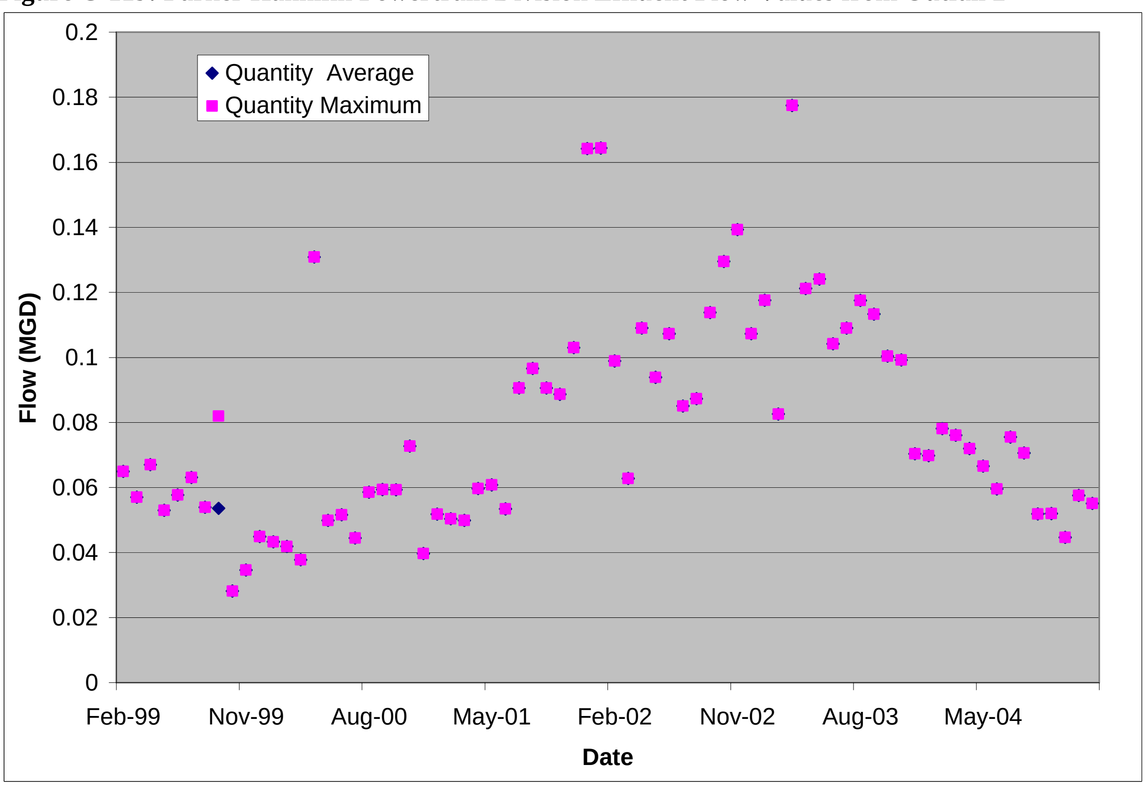


Figure C-120: Parker Hannifin Powertrain Division Effluent pH Values from Outfall 2

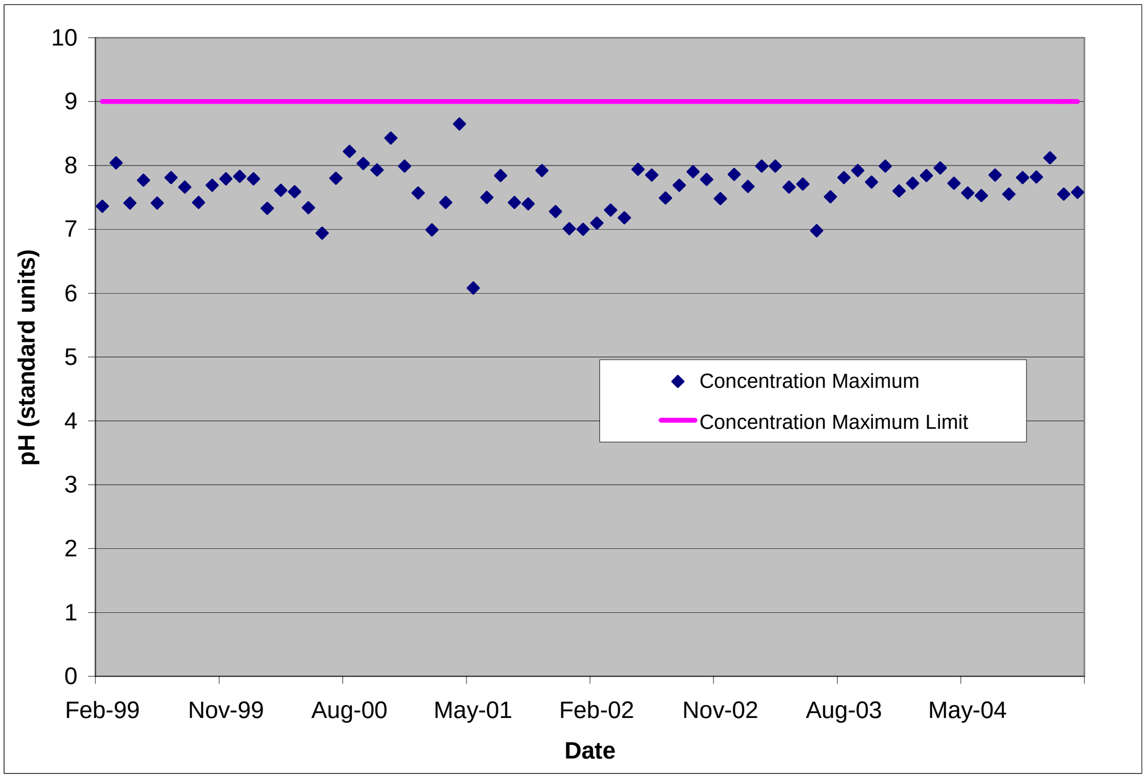


Figure C-121: Parker Hannifin Powertrain Division Effluent Temperature Values from Outfall 2

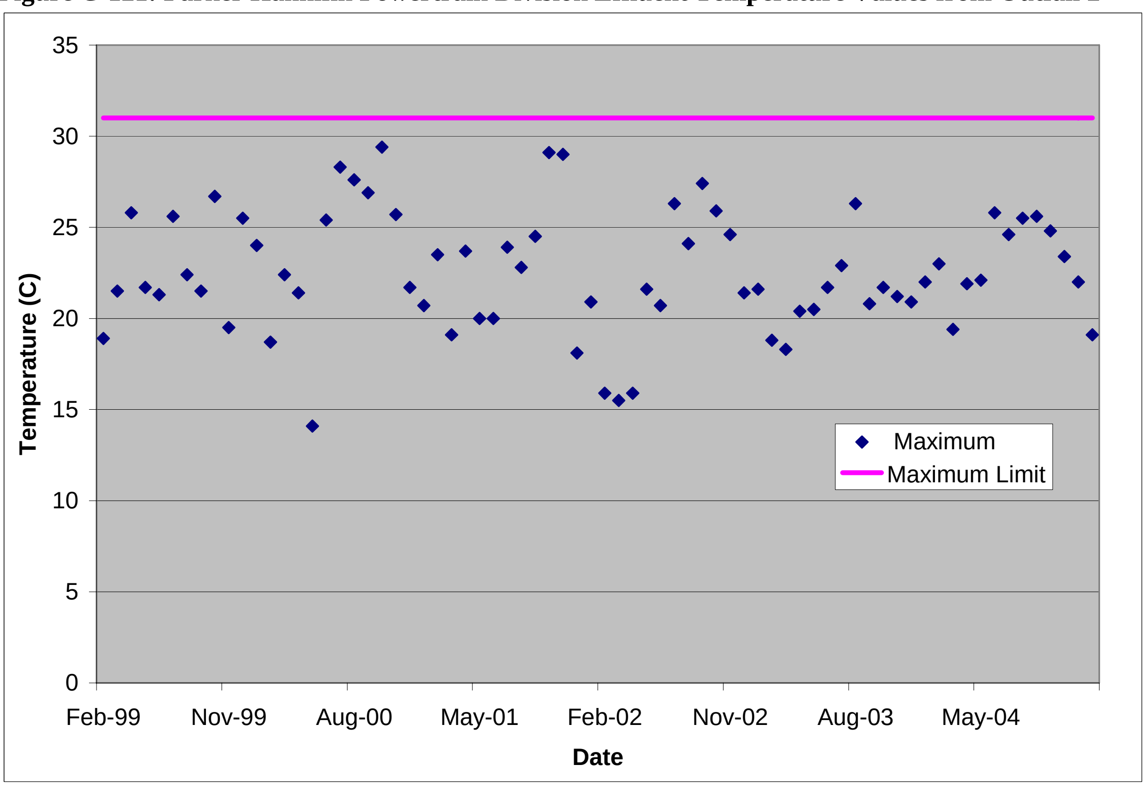


Figure C-122: Sponaugle Subdivision Effluent Flow Values

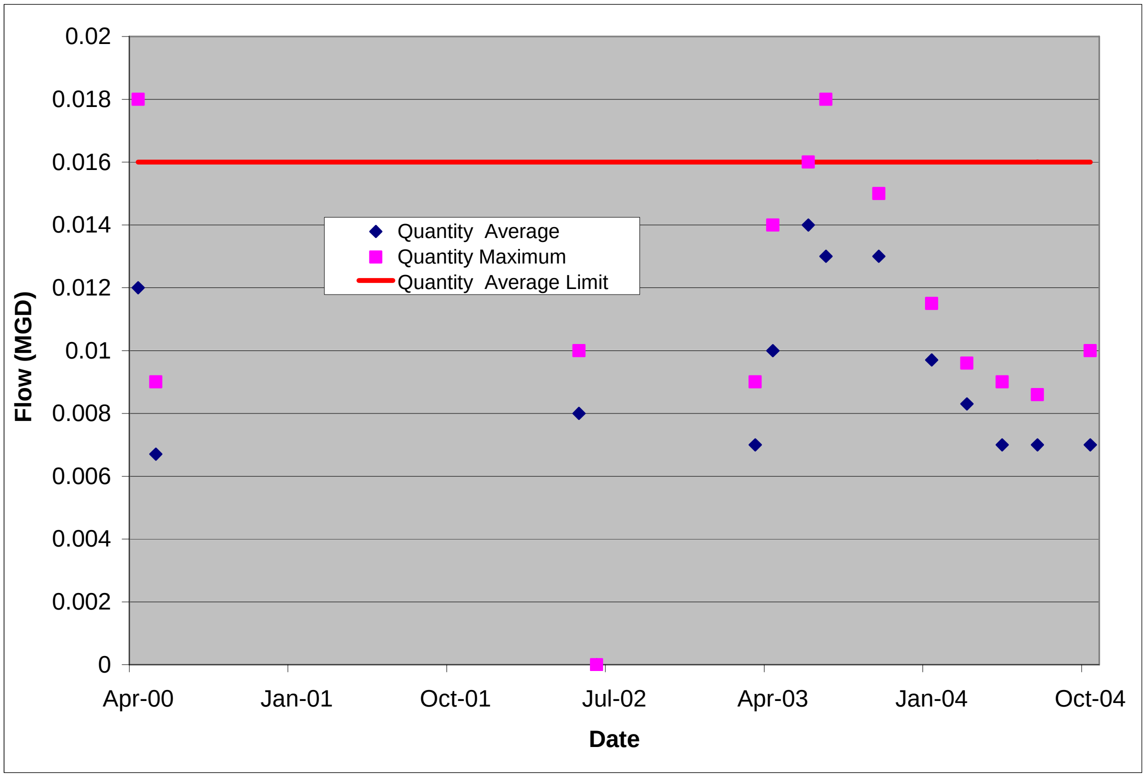


Figure C-123: Sponaugle Subdivision Effluent Cl2 Concentrations

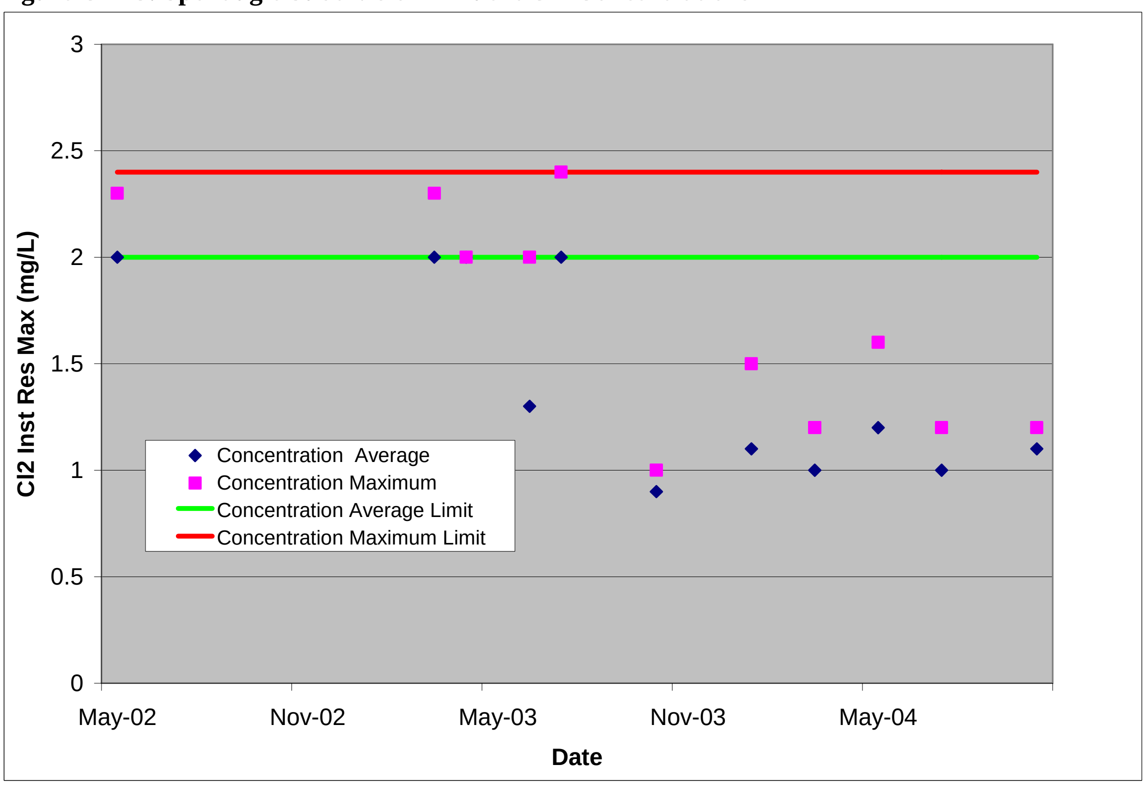


Figure C-124: Sponaugle Subdivision Effluent TSS Quantities

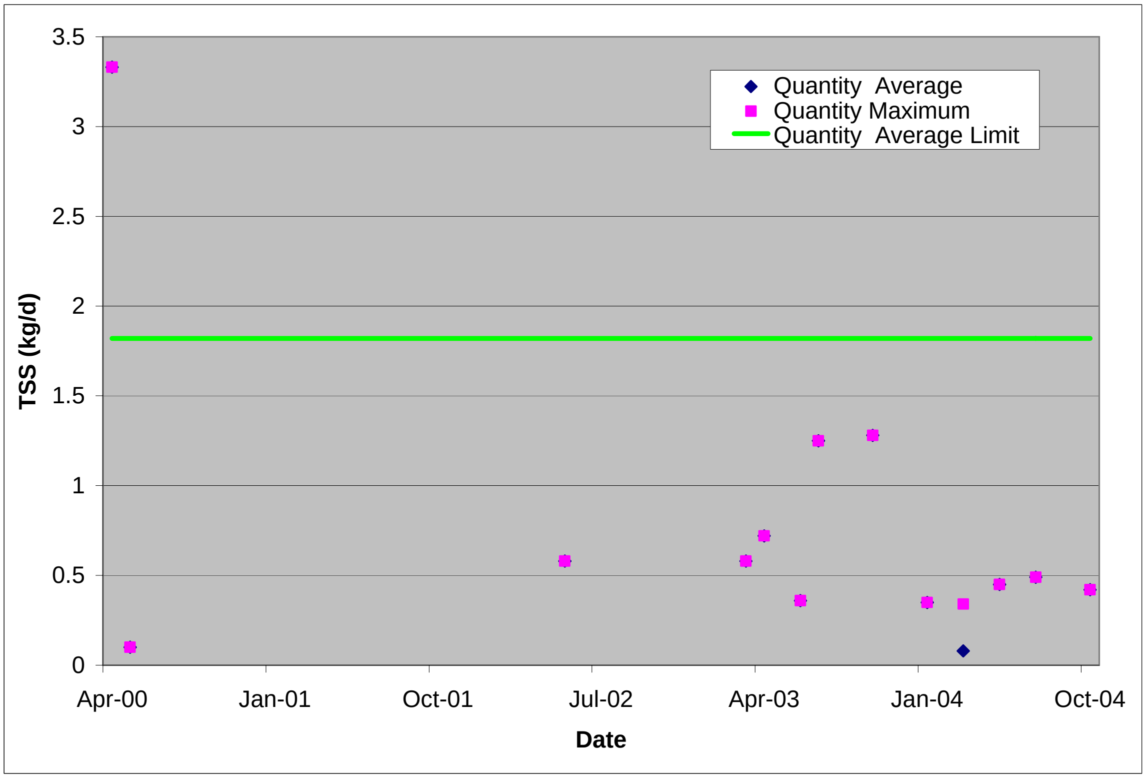


Figure C-125: Sponaugle Subdivision Effluent TSS Concentrations

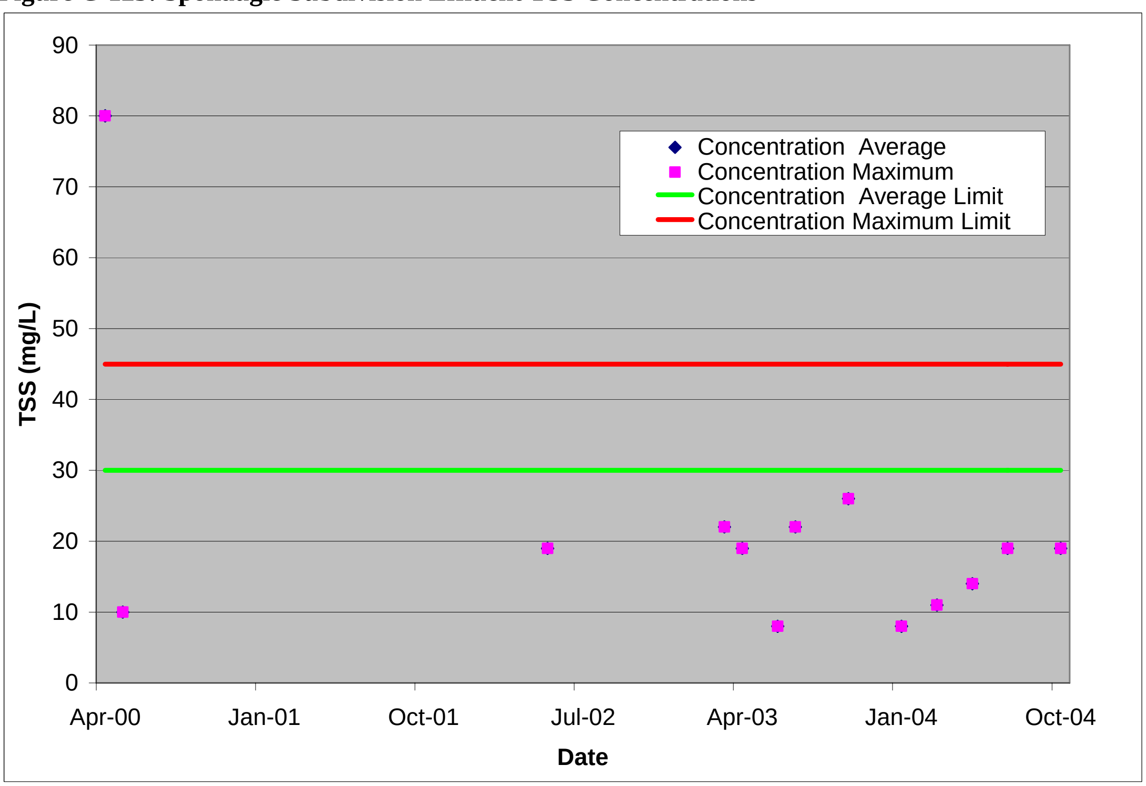


Figure C-126: Sponaugle Subdivision Effluent BOD5 Quantities

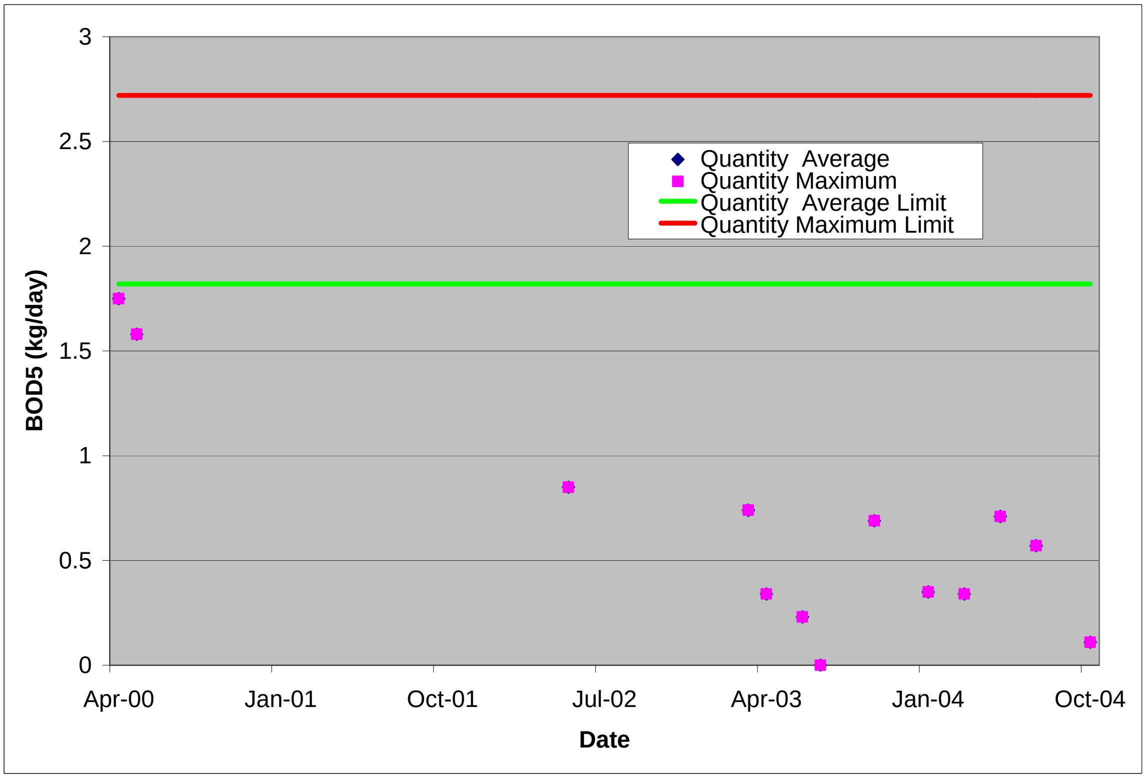


Figure C-127: Sponaugle Subdivision Effluent BOD5 Concentrations

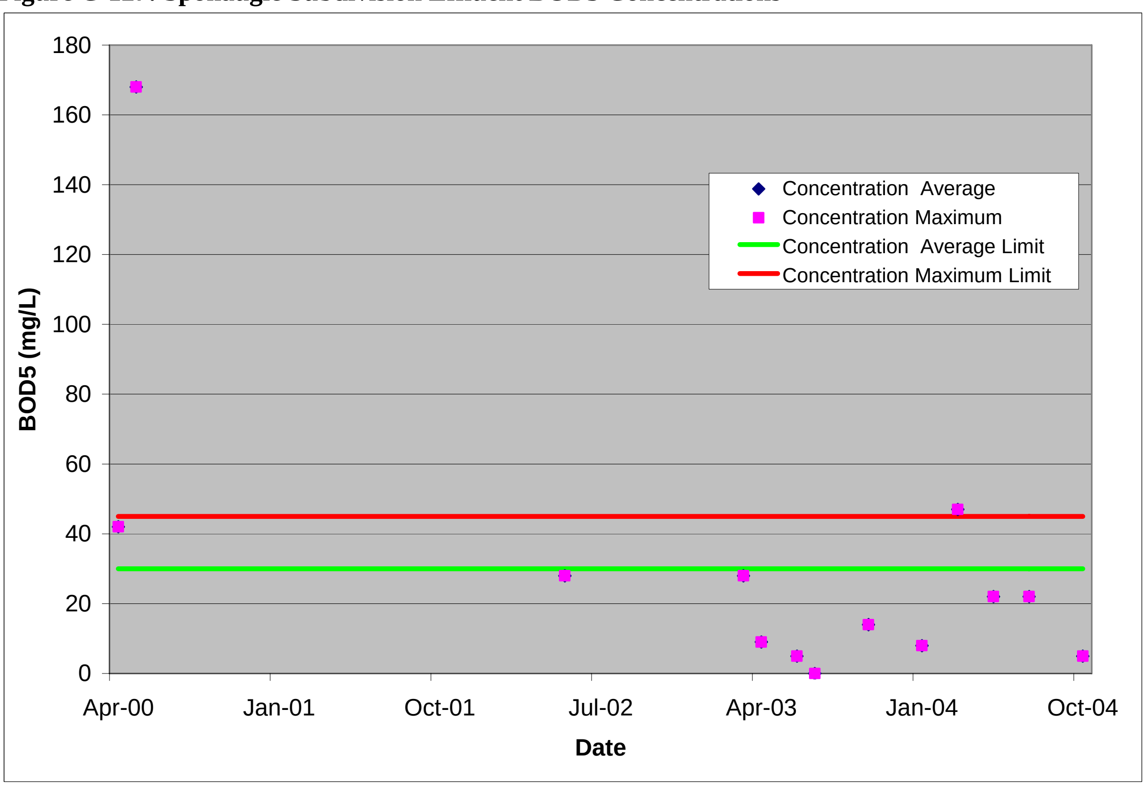


Figure C-128: VDOT I64 Rest Area - Alleghany Co. Effluent Flow Values

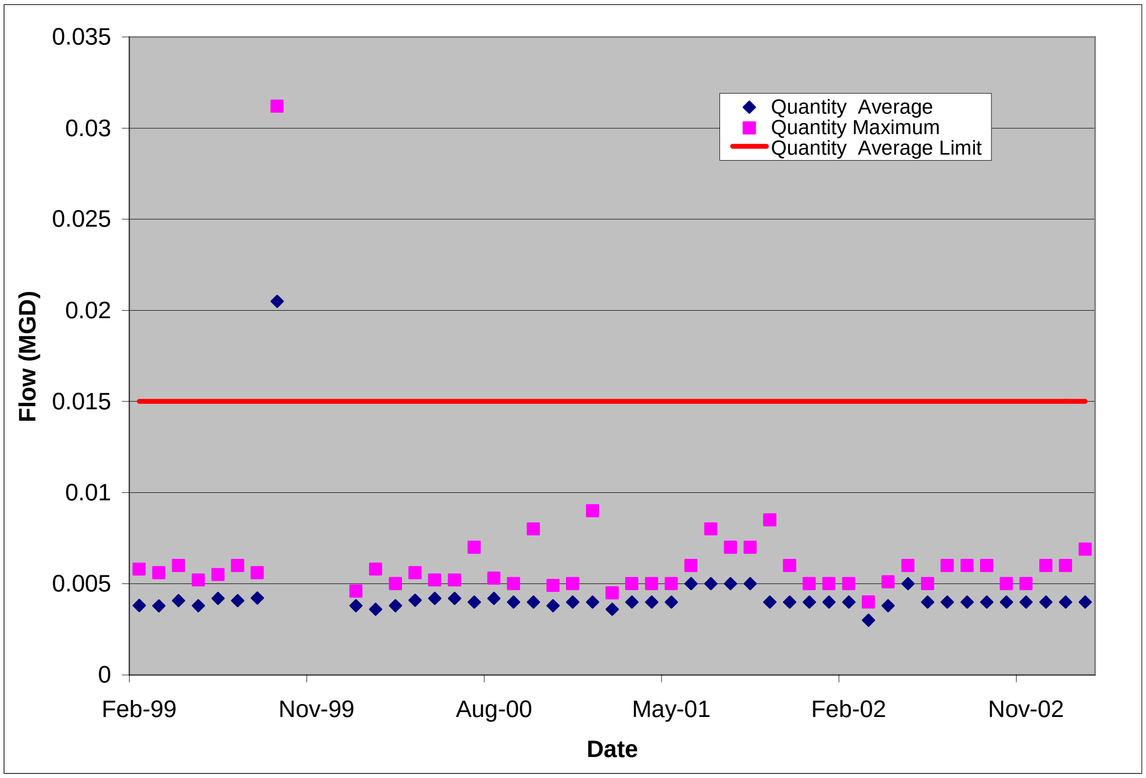


Figure C-129: VDOT I64 Rest Area - Alleghany Co. Effluent pH Values

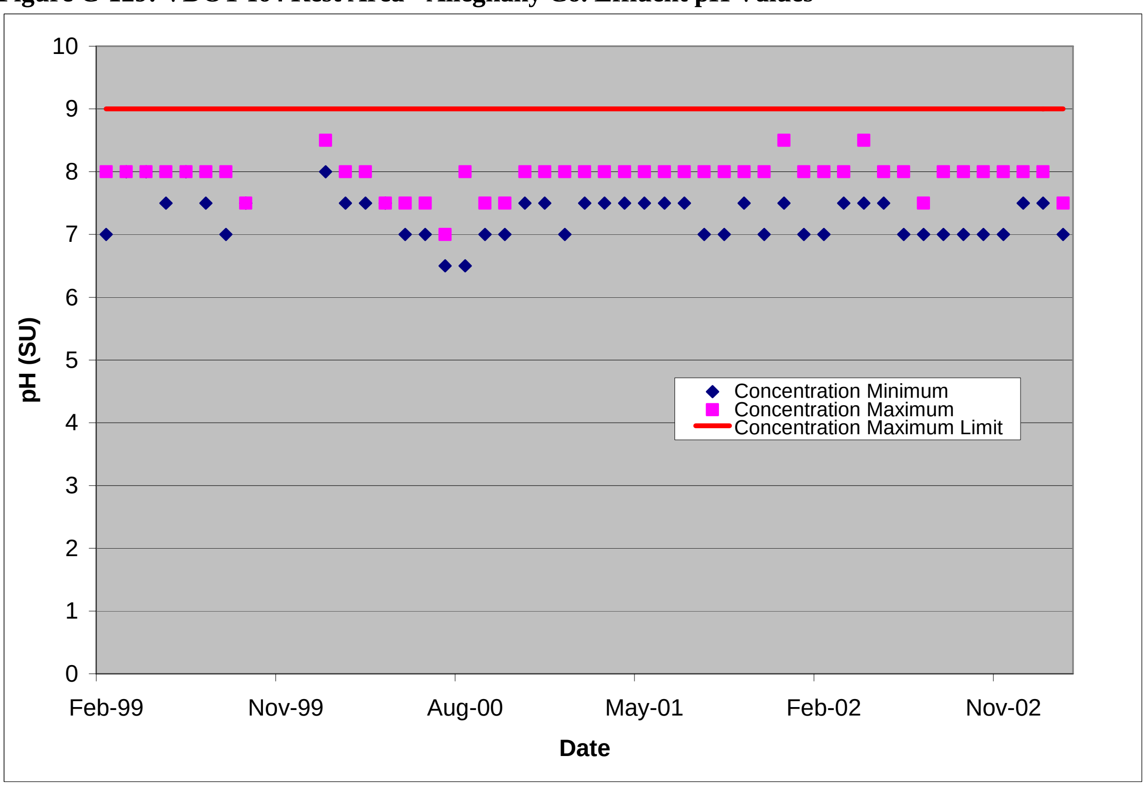


Figure C-130: VDOT I64 Rest Area - Alleghany Co. Effluent Dissolved Oxygen Concentrations

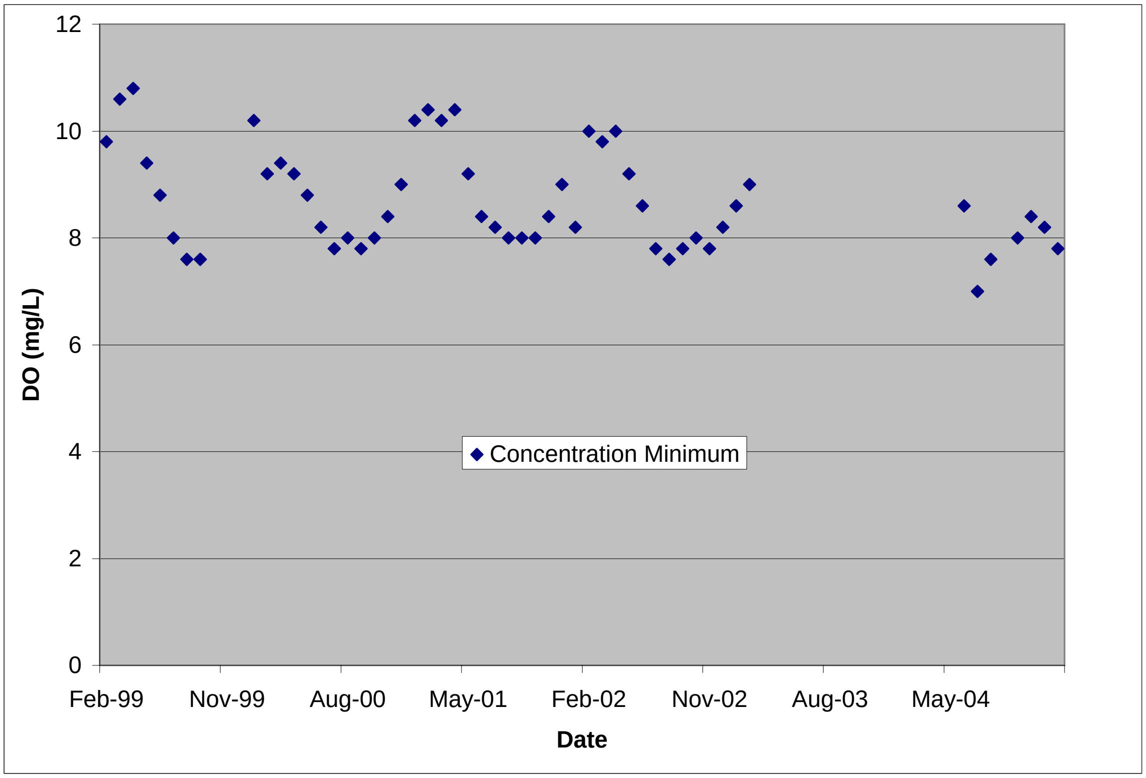


Figure C-131: VDOT I64 Rest Area - Alleghany Co. Effluent BOD Quantities

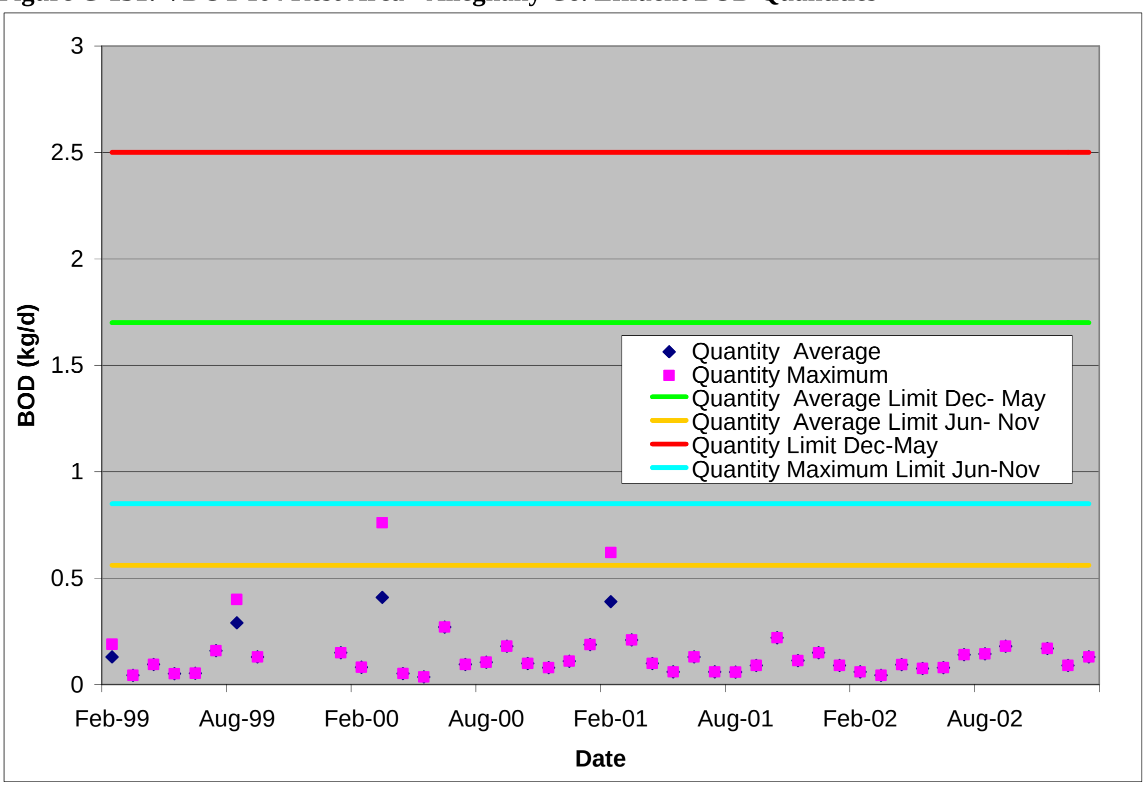


Figure C-132: VDOT I64 Rest Area - Alleghany Co. Effluent BOD Concentrations

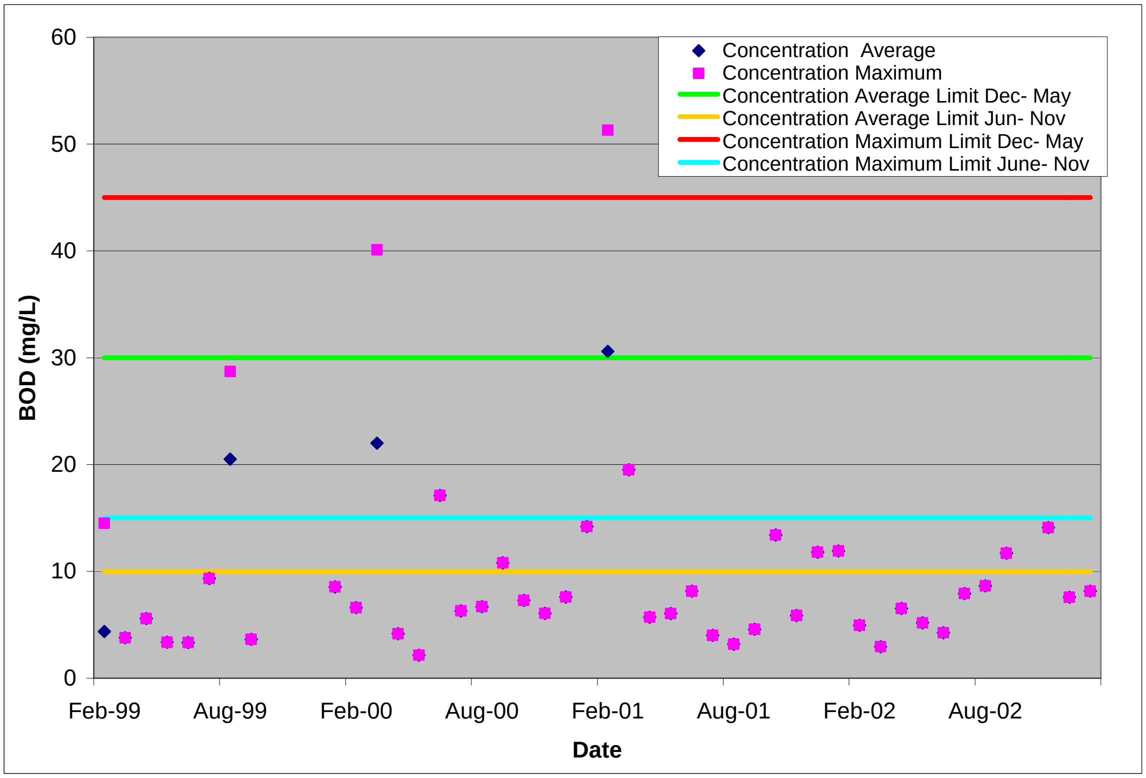


Figure C-133: VDOT I64 Rest Area - Alleghany Co Effluent TSS Concentrations

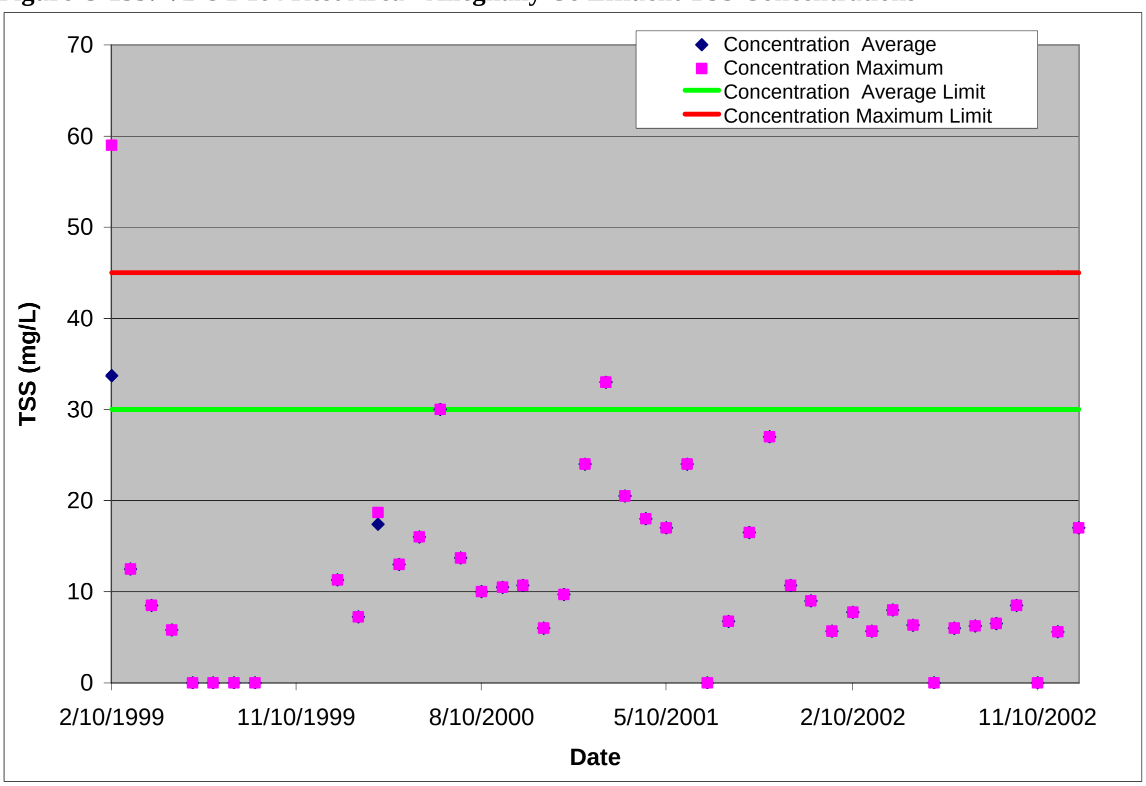


Figure C-134: VDOT I64 Rest Area - Alleghany Co Effluent TSS Quantities